Presentation I

T1: Evaluation of Factors that Might Modify the Benefit of Remote Limb Ischemic Conditioning on Motor Learning in Older Adults

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Introduction:
Ischemic conditioning is a phenomenon by which brief, sub-lethal bouts of ischemia and reperfusion protect a tissue, such as the heart or brain, from successive ischemic insults. Remote limb ischemic conditioning (RLIC) is a clinically feasible method of delivering ischemic conditioning through repeated inflation and deflation of a blood pressure cuff on an extremity. Recent work in our lab showed that RLIC robustly enhances motor learning in young, healthy humans. Potential applications to clinical populations receiving rehabilitation are numerous. It has not been determined, however, which patients would receive maximum benefit from RLIC. Numerous factors, such as age, gender, body mass index (BMI), and comorbidities likely influence the response to RLIC, based on preclinical and human cardioprotection studies. The current study aims to determine the effect of these factors on the facilitation of motor learning by RLIC.

Methods:
Participants aged 40-80 were enrolled and randomized to receive either RLIC or sham conditioning (5 cycles of 5 minutes inflation/5 minutes deflation of the blood pressure cuff on the upper extremity). RLIC consisted of inflation of the cuff to 20mmHg above resting systolic blood pressure, while sham conditioning consisted of inflation of the cuff to 10 mmHg below resting diastolic blood pressure. Participants underwent 7 consecutive weekday sessions consisting of RLIC or sham conditioning and motor training on a balance task, with 2 follow-up sessions. The last 5 balance trials each day were averaged and compared across participants, groups, and the factors of age, gender, BMI, and comorbidities.

Results:
Participants in both groups improved their performance on the stability platform balance task from pre- to post-test. Compared to our previous studies in healthy young adults, older adults learned the balance task at a slower rate. Furthermore, BMI and cardiovascular comorbidities may interact in this population to decrease responsiveness to RLIC and limit the facilitation of motor learning. Data collection is ongoing.

Conclusions:
RLIC may be a promising tool for enhancing motor learning and recovery in certain neurorehabilitation patient populations, but factors including cardiovascular comorbidity and BMI may limit its effect. As with cardioprotection studies, it is unclear what BMI represents (e.g. obesity, nutritional status, level of physical activity) in the context of its effect on the response to ischemic conditioning. Future studies will seek to optimize the RLIC protocol and determine which kinds of training are enhanced by RLIC.
T2: Functional Changes Secondary to a 6-Week Hand Training Program Using a Novel Concept Rehabilitation Device

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Background & Purpose:
A majority of stroke survivors experience significant loss of hand function. Current rehabilitation research that targets hand function improvement, is largely associated with complex active robotic devices that are expensive and need some expertise to operate. To access these devices, stroke survivors are generally required to be in the care of a rehabilitation professional which makes access both cumbersome and expensive. This study aims to examine the efficacy of a community-based training program that uses an innovative, portable, low-cost, passive rehabilitation device designed to improve hand function in stroke survivors.

Methods:
Eight participants (three female) who were at least five months’ post-stroke were recruited for the study. Participants underwent a six-week program consisting of 18, one-hour training sessions using a passive hand rehabilitation device. Force, range of motion, speed of contraction and coordination were randomly altered throughout the training sessions while participants performed various grasping tasks (pincer, tripod and spherical grasp) relying primarily on proprioceptive feedback and indirect visual feedback to aid in task performance. Participants’ affected hand was covered to prevent direct visual observation during task performance. Functional outcomes were measured using two objective methods; CAHAI-9, Box & Block Test, and one subjective test - ABILHAND. A paired t-test was used to estimate the differences between the pre- and post-training program assessments.

Results:
Results indicated that participants’ CAHAI-9 scores improved from pre-training (Mean 32.11 ± 15.24 SD) to post-training (Mean 37.89 ± 14.29 SD), and these differences were statistically significant (t7 = -3.37, p = .004). Box & Block Test results revealed no statistically significant results for the affected hand; however, a statistically significant increase in difference was observed for the scores assessed on the unaffected hand (t8 = -3.27, p = .006). Similar to CAHAI-9, the subjective assessment - ABILHAND scores improved from pre-training (Mean 23 ± 12.33 SD) to post-training (Mean 29.38 ± 9.74 SD), and these differences were statistically significant (t8 = -2.49, p = .02). This suggests that participants’ hand function improved as a result of the hand function training program using the innovative device.

Conclusions:
These results indicate that the six-week hand training program resulted in an increase in hand function, as demonstrated by both the subjective and objective assessments. While the improvements in functional abilities providing interesting preliminary results; additional enquiry is required in order for expansion and generalization of results to the general population of stroke survivors.
T3: Intensive Non-Paretic Arm Training in Chronic Stroke Patients with Severe Paresis Improves Functional Independence without Compromising Paretic Arm Function

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We previously demonstrated functionally limiting hemisphere specific motor deficits in the non-paretic, ipsilesional arm of chronic stroke patients. In a small pilot study in patients with severe paresis, we showed that non-paretic arm deficits can improve with non-paretic arm training. We now extend this study to a larger two-track cross-over design that includes both non-paretic arm training and sham training. We ask whether non-paretic arm training can improve functional independence, without detriment to the paretic arm, and we explore the durability of these effects. This report includes only one track of our study, for which we have thus far collected data in stroke survivors with moderate to severe paresis over a 12-week interval with 5 testing sessions that assessed non-paretic arm function, functional independence, and paretic arm impairment. After the initial assessment (Test 1), participants were retested (Test 2) after 3-weeks to confirm test re-test reliability and stability in baseline performance. During the following 3 weeks, participants engaged in intense ipsilesional arm training for three 90 minute sessions per week. During training, patients engaged in virtual reality (VR) games that required rapid and accurate motions of the non-paretic arm for 45 minutes. Following VR activities, the patients engaged in real-life activities involving resistive exercise, and challenging use of the non-paretic arm. After a post-test (Test 3), participants engaged in 3 weeks of sham training involving playing computer and board games to control for non-specific effects. They were again tested following the sham training (Test 4), and again after 3 weeks to assess durability of training (Test 5). For the non-paretic arm, our primary dependent measures were: 1) Jebsen-Taylor Hand Function Test (JTHFT), 2) The motor subscale of the Functional Independence Measure (FIM), and 3) Hand dynamometry. For the paretic arm, our primary dependent measure was the Fugl-Meyer Assessment. Our preliminary results indicate substantial improvements in response to non-paretic arm training in non-paretic arm performance (JTHFT) and functional independence (FIM), but not in general strength (dynamometry). This suggests that improvements were in coordination. Importantly, the paretic arm showed a modest, but significant reduction in impairment. Our results suggest that training of the ipsilesional arm in stroke survivors can improve non-paretic arm performance, which generalizes to improve functional independence. These improvements are durable over time, and this training is not detrimental to paretic arm function, and may slightly decrease paretic arm impairment.
T4: Neural Correlates of Within Session Changes on a Simulated Feeding Task in Individuals with Mild Motor Impairment After Stroke

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Introduction:
While the neural correlates of motor performance after stroke have been studied, less is known about the neural correlates of within session changes in response to motor practice. The integrity of white matter pathways other than corticospinal tract (CST), such as the superior longitudinal fasciculus (SLF) that connects premotor and parietal brain regions, may be important for such within session changes. The purpose of this study was to investigate the neural correlates of initial performance versus within session changes with practice on a simulated feeding task in individuals with mild motor impairment after stroke.

Methods:
Nine individuals with chronic stroke (age: 59 (5.60); months post-stroke: 15(5.60)) underwent diffusion tensor imaging (DTI) to determine white matter integrity and completed a set of standard upper extremity (UE) clinical performance measures and a functional motor task that simulates feeding. This task has also been shown to induce practice effects that indicate motor learning. Fractional anisotropy (FA) in the CST and the SLF were extracted from both hemispheres; FA from the lesioned side was normalized to FA from the non-lesioned side. In a single session, individuals completed the Box & Blocks Test, grip strength, and the hand domain of the Stroke Impact Scale. Following these measures, participants completed 15 trials of the motor task (1 trial=picking up and moving 9 beans with a spoon) and performance time was averaged into five trial blocks. The relationship between simulated feeding task performance (initial performance on Trial 1, change with practice) and both clinical performance measures and FA in the CST and SLF was examined with correlation analyses.

Results:
Individuals improved their performance on the simulated feeding task with practice (p<0.01; mean change -3.26± 2.75 secs). Clinical performance measures correlated with Trial 1 performance on the feeding task (Grip Ratio =-0.758, p=0.011; Hand Score SIS =-0.683, p=0.030; Box and Blocks Ratio =-0.673, p=0.033p<0.05) but did not correlate with within session changes with practice ( < 0.33). FA in the SLF correlated with change in performance with practice on the simulated feeding task ( = -0.717, p=.030) but not with Trial 1 performance. Lesion load to the SLF region of interest correlated with FA ( = -0.845, p=.004) but not change in behavioral performance. FA in the CST did not significantly correlate with Trial 1 performance or change with practice ( < 0.550, p>0.125).

Conclusion:
These findings suggest that the within session changes on the motor task were related to the integrity of the SLF, but not the integrity of the CST or clinical measures of the motor system in individuals with mild motor impairment after stroke. Further research is needed to determine the role of SLF in longer-term motor learning after stroke, including retention of performance.
The PREP algorithm can be used within days of stroke to predict upper limb motor outcomes 3 months post-stroke. The algorithm sequentially combines clinical, neurophysiological and neuroimaging measures to predict one of four functional outcomes for individual patients based on Action Research Arm Test score at 3 months (Excellent, Good, Limited, Poor). The PREP algorithm was recently validated in a study of 192 patients recruited within 3 days post-stroke. The aim of this study is to evaluate whether PREP predictions made at baseline are correct at 2 years post-stroke. Of the 157 patients who completed assessments 3 months post-stroke, 83 patients have completed 2 year follow-up assessments thus far. The PREP prediction at baseline was correct for 70% of patients 2 years post-stroke. Upper limb outcome category was better than predicted for 14% of patients, and worse than predicted for 16%. Upper limb outcome category was stable between 3 months and 2 years post-stroke for 81% of patients. Over this time 11% of patients improved to a better outcome category, and 8% deteriorated to a worse outcome category. There were no differences in baseline age, National Institutes of Health Stroke Scale score, or Charlson Co-morbidity score, between patients whose upper limb outcome remained stable, improved or worsened between 3 months and 2 years post-stroke. Upper limb impairment assessed with the Fugl-Meyer scale was stable between 3 months and 2 years post-stroke for those patients whose functional outcome was stable (mean Δ 1.8 points, 95%CI 0.6 - 3.1). In contrast, Fugl-Meyer scores decreased for patients whose functional outcome worsened (mean Δ -9.6, 95%CI -20.4 - 1.3) and increased for patients whose functional outcome improved (mean Δ 7.2, 95%CI 3.9 - 10.5). Paretic upper limb use was evaluated with the Motor Activity Log (MAL) 6 months and 2 years post-stroke. MAL scores were stable for those patients whose functional outcome did not change (mean Δ 0.1 points, 95%CI -0.2 - 0.4) or improved (mean Δ 1.4, 95%CI -0.5 - 3.2). In contrast, MAL scores decreased for patients whose functional outcome worsened (mean Δ -3.8, 95%CI -7.1 0 -0.4). These results indicate that PREP algorithm predictions made within days of stroke remain accurate at 2 years post-stroke. They also demonstrate that 3 months is an appropriate time point for upper limb predictions, as impairment, function and use of the paretic upper limb remained stable between 3 months and 2 years for the majority of patients. These results confirm that most patients make most of their upper limb recovery during the first 3 months after stroke.
Previous studies indicate that increasing the perceived hand size with magnifying lenses improves tactile discrimination, reduces pain perception, and induces changes in action performance. In a cohort of twenty-five chronic stroke survivors, we showed that motor skills, tested with grip force, finger tapping and reaching and grasping tasks, improve when actions were performed with magnified compared to normal vision of the hand. To investigate the possible application of visual magnification for home-based treatment, eleven patients were selected from this cohort as they showed an improvement of at least 10% in grip force and/or finger tapping. Six of the 11 patients who had improved with magnification underwent a two-week home-based training program, in which they were required to perform different tasks (coloring a coloring book, completing puzzles) using a magnifying glass (1.8x normal size). Patients’ motor skills were measured before, immediately after, and after two weeks from the end of the training. Five of 6 patients showed an improvement in most of the motor tasks when tested immediately after the training. These beneficial effect of training persisted in time as patients’ performance was better two weeks after training than the pre-training testing session. These results suggest that the magnification of vision is a potential tool for the rehabilitation of motor function in patients with stroke.
T7: Enhancing Recovery of Cognitive Function in Individuals with Post-Concussion Syndrome Using Electrical Stimulation on the Neck Paraspinal Muscles

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Background:
Post-concussion syndrome (PCS) is a complex disorder in which various symptoms such as headaches, dizziness, sleep disturbances, last for weeks and sometimes months after the concussion occurred. In spite of many recommendations existing for PCS management, there are still many uncertainties as to treating PCS especially those individuals suffering with upper cervical spinal injury. Individuals with PCS suffering with upper cervical spinal injury might have compromised vesibulo-thalamo-cortical pathways or other pathways anatomically located posteriorly in the body that are involved in cognition. While electrical stimulation (ES) has been extensively used to modulate the brain and reflex activities, it can be beneficial on recovery of cognitive function. The objective of this study was to examine the efficacy of neck paraspinal muscles ES in conjunction with the physical therapy (PT) on reducing the PCS symptoms load compared to PT alone. We hypothesized that both groups demonstrate positive outcomes but the cognitive function of ES group recovers at a faster manner.

Participants:
Twenty-three individuals with PCS were recruited in the study and randomly assigned to the ES group (PT + ES) or the control group (PT only). Eleven participants (two male and nine female, 31.5 ± 18 years old) were in the ES group. Twelve participants (six male and six female, 29.8 ± 14 years old) were in the control group. All participants were recruited from the Emerson Hospital in Concord MA.

Methods:
Participants received the treatment (PT+ES or PT only) twice a week for eight weeks. MyoWork™20 was used to deliver ES. The intensity was adjusted according to the comfort of participants. In addition to routine clinical measures, to track the symptom changes, we used the Dr. Cantu Symptom Check List including 26 symptoms and loads filled by participants before each treatment session started. We investigated the progression of recovery by calculating slopes of changes over time in each participant. A changing slope was derived by linearly fitting the symptom load over time with the initial load value as the intercept. We hypothesized that the ES enhances the cognitive function recovery (in the other word, a more negative slope for symptom load changes). Independent T-test (one-tailed) was used to assess the differences between two groups.

Results:
The significant overall improvement was observed in both groups in all measures. There was no significant difference in overall recovery between two groups (-1.49 ± 1.59 versus -1.2 ± 1.56, p=0.32) but the averaged symptoms load changing of ES group was faster than the control group (-0.5 ± 0.49 and -0.13 ± 0.46 respectively, p= 0.04).

Conclusions:
Modulating vestibular pathways through non-invasive electrical stimulation on the neck paraspinal muscles could potentially speed up the cognitive functions recovery in individuals with PCS.
Peripheral nerve disorders are a major cause of disability in the United States, and presumably have a greater impact on the life of patients whose dominant hand (DH) is impaired, compared to patients whose non-dominant hand (NH) is impaired. However, we know of no studies that directly addressed the effects of hand dominance on peripheral nerve patient disability. Here, we addressed this question by reanalyzing an existing database containing 323 unilateral peripheral nerve disorder patients of known handedness (Stonner et al. 2017, Amer J Occupational Therapy). We expected that patients with DH impairment would show greater disability than patients with NH impairment.

Our primary outcome measures were three surveys of patient disability: Disabilities of the Arm, Shoulder, and Hand (DASH), DASH Work Module, and Short Form 8 Physical Component Score (SF-8 PCS). We analyzed the data in two steps, repeated for each outcome variable with appropriate Bonferroni correction. We performed one-way ANOVAs of univariate analyses of affected-side (DH or NH) on disability, followed by multivariate analysis (stepwise multiple linear regression). Candidate factors included affected-side, left/right dominance, duration of symptoms, prior surgeries, diagnosis category, and 4-10 preselected confounds specific to each outcome variable. This study was preregistered via the Open Science Framework at the Center for Open Science.

Unexpectedly, affected-side had no effect on any of the main outcome measures ($p > 0.2$). However, exploratory analysis revealed a strong effect of affected-side on two of the 30 questions in the DASH survey: "difficulty writing" and "difficulty turning a key" ($p < 0.0001$). These two are the only questions that specifically refer to unilateral actions in the DASH or any other outcome survey. Therefore, we conclude that DH impairment (compared to NH impairment) can impact patients’ ability to perform common unilateral activities, but standard clinical measures of disability may not capture these hand-specific impairments.
Objectives:
Spinal plasticity induced by brain trauma or stroke may underlie pathological changes in motor reflexes and locomotion. Knowledge of pathological spinal plasticity is very limited. The striking phenomenon of spinal cord plasticity induced by brain injury was discovered by Anna Di Giorgio in 1929. In these experiments, unilateral lesion to the cerebellum resulted in hind limbs postural asymmetry exhibited as ipsilateral hind limb flexion. The asymmetry retained after spinal transection suggesting side-specific plastic changes in the spinal cord. We here examined whether focal cortical injury induces similar phenomenon and searched for underlying neurobiological mechanisms.

Methods:
Unilateral cortical injury (ablation by aspiration or controlled cortical impact, CCI both centered on cortical hindlimb representation area) in rats. Behavioral and EMG analysis of postural asymmetry / reflexes. qRT-PCR, ddPCR, IH, ISH.

Results:
Unilateral cortical injury induced hind limb postural asymmetry that retained after spinal cord transection. The right-side injury resulted in the left hind limb flexion. Administration of the general opioid antagonist naloxone or selective mu-antagonist beta-FNA but not selective delta-antagonist naltrindole inhibited formation of postural asymmetry. Surprisingly, selective kappa-antagonist nor-BNI reversed the side of the flexed leg in CCI rats. The reversion was evident prior to and after spinal transection. Selective kappa-agonists U50488 or dynorphin under i.t. or i.v. administration mimicked the effects of right-side CCI by inducing the left limb flexion in naive animals. Consistently, lateralized expression of opioid receptors was revealed in the spinal cord.

Conclusions:
We developed a new animal model in which the unilateral controlled cortical impact injury (CCI), a clinically-relevant model of traumatic brain injury, produces changes in the spinal cord manifested as postural asymmetry with flexion of the contralesional hindlimb in rats. Analysis of this phenomenon demonstrated that brain injury-induced impairment of hindlimb motor functions is encoded at the spinal level, and that the endogenous opioid system has a critical role. Furthermore, we demonstrated that the opioid system is lateralized in the spinal cord, and as such may be involved in unilateral CCI-induced side-specific plastic changes in the spinal cord, which contribute to development of motor deficits including hemiparesis and hemiplegia. The data suggest that targeting of the opioid system with opioid antagonists could open a window of possibilities for pharmacological correction of motor deficits secondary to stroke and traumatic brain injury.

Published Papers:
T10: Falls among Stroke Patients during Inpatient Rehabilitation in a Tertiary Care Rehabilitation Hospital in Saudi Arabia: Incidence and Risk Factors

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Introduction:
Stroke patients who go through rehabilitation often suffer from diversity of cognitive and physical deficits, placing them at high risk of falling. Falls are serious events for stroke patients admitted to inpatient rehabilitation. Following a stroke, people are at high risk of falls. Creating improved fall prevention strategies early after stroke requires an accurate understanding of fall risks and predictors. Falls during rehabilitation were recognized as strong predictors of subsequent falls after discharge. Falls have been associated with considerable morbidity that may lead to increased length of stay and medical cost.

Objectives:
The objective of this study was to investigate the incidence and risk factors of falls among stroke patients during inpatient rehabilitation in a tertiary care center in Saudi Arabia.

Methods:
Retrospective study conducted using medical charts (electronic and paper). All Stroke Patients admitted for Inpatient Rehabilitation was included in study. Fall characteristic of stroke patient who fell during rehabilitation were documented on data sheet. All analyses were performed using SAS software.

Results:
146 stroke patients were admitted from Jan 2011 to June 2013 in rehabilitation hospital.

A total of 36 patients out of 146 had falls. Among 36 fall patients, 28(77.78%) were male and 8(22.22%) were female. Age range from 42 -82yrs(Mean 59.64 yr). A left-sided stroke was more common (55.56%). The strokes were predominantly ischemic in origin (26%). The frequencies of preexisting medical conditions among the patients shows that hypertension(83.4%), diabetes mellitus (65%), prior stroke(33.3%), and communication disorders (66.67%), were the most common preexisting conditions. Hypotensive medications 83.4%, antidepressants 25%, anticonvulsants 11.11% were commonly used medication among fall patients.

Rate of fall was 2.85 falls per two months. 61.1% of fall patients were high risk and 36.11% were moderate risk for fall. 83.33% had one fall and 36.11% had 2 falls. Most of patients 58.33% fell during morning shift. Most fell from bed 52.78% then from chair 27.78%. Most of falls 61.2% were unobserved and reported after the fall. In 75%, the patient's room was most common location. Length of stay of in 24 (66.8%) of the fall patients was more than 45 days. Length of stay was significantly associated with rate of fall (P=0.0162).

Conclusion:
Stroke patients in this study had a significant fall rate during rehabilitation. Most patients who fell did so for the first time. The hospital stays of those who fell were significantly longer. The rehabilitation goals should be set in the activity dimension and focus on the most hazardous activities such as transfers, position changes and performing tasks while seated and in the patient room. One of the preventive measures employed at this facility include at admission and post fall meetings. Decision for out on pass should be taken once patient and family ready for this. Education and informative video for patient and family. The implementation of sensor system in Rooms for high risk patients.
Abnormal coupling of shoulder abduction and elbow flexion, referred to as flexion synergy, limits reaching function following stroke. The feasibility of improving reaching function in individuals with chronic moderate to severe stroke has been demonstrated previously through the employment of targeted rehabilitation robotics identifying progressive abduction loading as a key therapeutic element. In the present study, we expanded upon the investigation of efficacy by testing a potentially augmentative parameter of the exercise, enrolling a larger sample, and including a 3-month follow-up evaluation. Primary outcome measures included kinematic measurement of reaching distance and peak velocity under standardized abduction loading and single-joint isometric shoulder and elbow strength. Secondary outcome measures included Arm Motor Fugl-Meyer, Rancho Los Amigos Functional Test for the Hemiparetic Upper Extremity, Motor Activity Log, and Stroke Impact Scale. Thirty-two participants with moderate to severe chronic stroke (Fugl-Meyer Arm baseline mean±SD, 26.7±6.5 out of 66) were randomized. All participants utilized the ACT3D robot to perform outward reaching (at shoulder height) with abduction loading to standardized outward targets for 1 hour, 3 times per week, for 8 weeks. Abduction loading was progressively increased based on performance thresholds for both groups however the experimental intervention also included horizontal plane viscous resistance. There were no differences between groups, however for both groups, normalized mean±SD reaching distance improved significantly (p < 0.05) from 0.69±0.28 at pre-test to 0.78±0.25 at post-test and persisted at 3-month follow up at 0.77±0.26. Single-joint isometric strength improved for constituent joint torques of reaching but did not persist at follow-up. There were no differences between groups for the clinical outcome measures, however for both groups, the impairment-level metric (Fugl-Meyer) increased significantly from pre-test (26.8±6.5) to post-test (28.9±6.9) and persisted at follow-up (29.5±7.1). Similarly, self-report on the Stroke Impact Scale of physical problems improved significantly from pre-test (0.45±0.15) to post-test (0.52±0.13) and persisted at follow-up (0.55±0.14) in both groups. Improvements were not observed in activity limitation or participation restriction metrics although self-report of overall recovery improved significantly (p < 0.05) from pre-test (61.9±18.0) to post-test (67.3±17.8). Persistent gains in reaching distance under abduction loading and Fugl-Meyer scores support an amelioration of flexion synergy impairment. The addition of viscous resistance to outward reaching did not enhance effects. Future work should investigate the feasibility and efficacy of implementing robot-mediated progressive abduction loading therapy in early recovery as adjuvant to conventional task-oriented therapy that is known to improve activity limitation but more so through the enhancement of compensatory strategies. Targeting flexion synergy may capitalize on the critical/sensitive period of neuroplasticity in early recovery by optimizing utilization of residual corticospinal tract that is necessary to produce movements outside of flexion synergy.
The concepts of spike timing-dependent stimulation have been applied to strengthen transmission of residual axons in the corticospinal tract for motor recovery after spinal cord injury (SCI). In both animal models and humans, synaptic efficacy between corticospinal axons and spinal motor neurons has improved temporarily after a short period of paired stimulation between motor cortex and spinal or peripheral sites. In a demonstration of closed-loop stimulation in incomplete SCI rats, target muscle electromyography (EMG) signals were used to trigger spinal cord electrical stimulation while performing physical retraining. Results showed that EMG-triggered spinal stimulation plus physical retraining led to greater motor recovery than non-triggered stimulation (open-loop) or physical training alone. However, these studies used invasive direct spinal cord stimulation in rodent models. Whether this approach can work non-invasively in humans remains unknown.

By coordinating peripheral stimulation with endogenous brain activity during intended movement, we hypothesize that EMG-triggered stimulation is an optimal method to enhance spike timing-dependent plasticity at spinal synapses: (1) EMG triggering requires subjects’ active involvement during stimulation; (2) a non-invasive approach could be combined with simultaneous task-oriented training; (3) peripheral stimulation can be timed to target spinal synapses. Therefore, this study will investigate non-invasive EMG-triggered closed-loop stimulation in humans as a proof of principle.

A working prototype of our EMG triggered closed-loop stimulation system has been developed. The system includes an EMG acquisition device, force dynamometer, microcontroller, transcranial magnetic stimulator (TMS), and peripheral nerve stimulator (PNS). A data acquisition (DAQ) board integrates the devices. Our self-developed LabVIEW program synchronously records thumb EMG and pinch force signals. Once the signal detection exceeds a target threshold, the DAQ board generates digital output to the microcontroller to trigger TMS, PNS, or both with specific stimulation intervals.

Our upcoming human testing will recruit twenty participants (10 able bodied and 10 SCI subjects. Each subject will undergo five different 20-minute interventions on separate days. Stimulation will be delivered at the motor cortex via TMS, the median nerve via PNS, or both. Stimulation will occur either while the subject is passively at rest or triggered by reaching EMG threshold during a pinch task. A session of voluntary contraction without exogenous stimulation will also be compared. Outcomes will be measured at baseline and every 20 minutes for one hour after the intervention. Outcome variables include motor evoked potential amplitude, cortical silent period, maximal voluntary pinch force, and time required to complete a pegboard task. We hypothesize that EMG-triggered stimulation will provide significant improvement compared with passively delivered stimulation. We further hypothesize that EMG-triggered PNS stimulation alone will provide equal or greater benefits as EMG-triggered TMS or EMG-triggered paired TMS+PNS stimulation. Non-invasive PNS stimulation has the advantage of being more practical to integrate into physical trainings.
Background:
Recent observations of "Proportional Recovery" post stroke suggest that upper and lower extremity motor function, visuospatial neglect, and aphasia can be predicted to recover 70% of one’s maximal potential. This recovery is independent of the amount of therapy provided. If this observation reflects spontaneous recovery, clinical rehabilitation outcome measures (i.e. balance and cognition) may follow similar recovery patterns.

Objectives:
1) To replicate previous findings showing proportional motor recovery. 2) To determine if recovery of balance and cognition also follow this recovery trajectory.

Methods:
Participants who had a baseline assessment 0-3 weeks post stroke and a follow up at 6 months post stroke were identified retrospectively from an existing stroke recovery database. Measures were selected based on those clinically available and with a defined maximum value. The Functional Independence Measure–motor subtotal (FIMmotor), Berg Balance Scale (BBS), Temporal Gait Asymmetry (GA), Functional Independence Measure-cognitive subtotal (FIMcog), were extracted. Observed change scores were calculated as the difference between the measure at 6 months and baseline. The predicted change was calculated as the difference between the maximum score on that scale, and the baseline score. Participants were excluded from subsequent analyses in a specific measure if at baseline they achieved the maximum possible score or if a negative change score occurred, indicating a decline in function. For each measure, we performed Pearson’s correlations to determine the relationship between observed and predicted change scores. Average percent recovery was determined as a ratio of observed change over predicted change.

Results:
Data from 33 participants (mean age 68.0±13.3 yr, 22 male) were analyzed. Moderate impairment was noted by an average NIHSS score of 4.9±3.1 and FIM total of 87.0±24.8. Statistically significant (p< 0.001) correlations between observed and predicted change scores were found for FIMmotor (r=.89), BBS (r=0.88), GA (r=0.88), and FIMcog (r=0.67) scores. Proportional recovery was 80% FIMmotor, 78.6% BBS, 66.8% GA, and 71.2% FIMcog.

Conclusions:
Proportional recovery approximating 70% was found for all measures. Proportional recovery was observed in components of stroke recovery not previously described, including balance and cognition. The findings suggest that this model may be useful to assist in goal setting for moderately impaired stroke survivors within 3 weeks of stroke.
Introduction:
The corticospinal tract (CST) is the main motor output pathway in humans. Damage to the CST from stroke leads to motor deficits, and can be quantified as the amount of overlap between the stroke lesion and CST, expressed as a percentage (% CST Injury). Previous studies show that stroke participants with greater % CST Injury have worse motor outcomes than those with lower % CST Injury. Thus, % CST Injury is a biomarker of the structural integrity of the motor system. In these studies, the stroke lesion is delineated from structural T1-weighted magnetic resonance imaging (MRI) scans, often acquired as part of research studies. In contrast, computed tomography (CT) scans are clinically obtained as part of routine care in many stroke centers. Thus, the aim of our study is to determine whether % CST Injury, using lesions traced from clinical CT scans, correlates with motor outcome post-stroke.

Methods:
Retrospective data was collected from the Heart and Stroke Foundation Canadian Partnership for Stroke Recovery Rehabilitation Affiliates Database. Participants were selected if they had a clinical CT scan and completed the Chedoke-McMaster Stroke Assessment Impairment Inventory (CMSA), which was administered as a standard clinical motor assessment. This assessment includes the Stage of Arm (CMSA-Arm) and Hand (CMSA-Hand) Impairment. The CT protocol included the following: in-plane resolution of either 0.45×0.45mm² or 0.49×0.49 mm²; slice thickness of 5mm; between 24 and 32 axial slices. Stroke lesions were manually traced from the CT scans using ITK-SNAP. Analyze10 software was used to remove non-brain tissue. FSL was then used to register the CT scans and stroke lesions to the Montreal Neurological Institute (MNI) 2-mm template with an affine transformation. The % CST Injury was calculated from the transverse slice of the CST with the greatest overlap with the lesion.

Analysis:
We performed Spearman’s correlations for: 1) % CST Injury and CMSA-Arm stage; and 2) % CST Injury and CMSA-Hand stage.

Results:
Data from 43 participants (26 males and 17 females; average age 67.8±13.1 years) were analyzed. One participant had missing data for the CMSA-Arm. The % CST Injury was significantly correlated with CMSA-Arm ($r_s(40)= -0.42; p=0.006$) and CMSA-Hand ($r_s(41)= -0.47; p=0.001$) stage.

Conclusion:
Our results demonstrate that participants with higher % CST Injury have worse motor outcome than those with less % CST Injury. These preliminary data suggest that we may be able to use clinically available CT scans to determine % CST Injury.
Comparison of Self-Report Vs. Sensor-Based Methods for Measuring Upper Limb Performance Outside the Clinic

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Background:
Individuals with stroke are referred for rehabilitation services to improve performance in daily life. Performance, defined as what a person actually does outside of a rehabilitation clinic or laboratory, is difficult to measure for the upper limb (UL). Researchers must choose between self-report measures of UL performance, which provide critical information about patient perception of change but are subject to inherent biases such as social desirability and recall bias, or sensor-based methods, such as accelerometry. Accelerometry is a valid, reliable, quantitative measure of UL performance in daily life and is not subject to the same biases as self-report measures, but cannot determine the specific activities someone performs. While self-report and sensor-based UL performance measures are moderately correlated, it is critical to know the accuracy and consistency between the two measures.

Objective:
To compare self-reported with sensor-measured upper limb (UL) performance in daily life in a clinical trial cohort of persons with chronic (≥ 6 months) UL paresis post-stroke.

Methods:
Secondary analysis of 64 community dwelling individuals with chronic (≥ 6 months) UL paresis post-stroke enrolled in a Phase II randomized, parallel, dose-response UL movement trial. This analysis compared the accuracy and consistency between self-reported UL performance and sensor-measured UL performance at baseline and immediately post an 8-week intensive UL task-specific intervention. The primary outcome measures were the Motor Activity Log-Amount of Use Scale and the sensor-derived use ratio from wrist-worn accelerometers.

Results:
There was a high degree of variability between self-reported UL performance and the sensor derived use ratio. Using sensor-based values as a reference, three distinct categories were identified: accurate reporters (reporting difference ± 0.1), over reporters (difference > 0.1), and under reporters (difference < -0.1). Five of 64 participants accurately self-reported UL performance both pre and post-intervention. Over half of participants (52%) switched categories from pre-to post-intervention (e.g. moved from under reporting pre-intervention to over reporting post-intervention). For the consistent reporters, no participant characteristics were found to influence whether someone over- or under-reported performance compared to sensor-based assessment.

Conclusions:
Participants did not consistently or accurately self-report UL performance when compared to the sensor-derived use ratio. While self-report and sensor-based assessments are moderately associated and appear similar conceptually, these results suggest self-reported UL performance is often not consistent with sensor-measured performance and the measures cannot be used interchangeably.
Introduction:
One of the major objectives of inpatient rehabilitation is to optimize patient and caregiver safety and efficiency in activities of daily living. Having a therapist observe a patient engaged in Robotic Upper Limb Therapy (RULT) is considered inefficient use of a therapist’s time and skill. The implied value of (RULT) is that it is safe, easily administered, considered interesting and challenging by the patient, and has value for enhancing motor recovery and improved self-care function. Current therapy reimbursal systems do not compensate for (RULT) unless it is part of an individual therapist-administered treatment. We therefore assessed the feasibility of (RULT) administered by a trained volunteer.

Methods:
The Volunteer had two 30-minute training sessions by an Occupational Therapist (OT) using the MIT-Manus Planar Upper Limb Robotic software applications, proper positioning of the patient, and device shut-off and safety considerations. Initial patient sessions were supervised by the patient’s OT until the Volunteer demonstrated satisfactory performance. Patients were referred by their OT for RULT if they could initiate horizontal gravity-eliminated movement of the forearm and could follow one step commands. They were enrolled in 25 minute (RULT) sessions based upon the Volunteer’s availability from one to three half-days per week. Functional Independence Measures and Fugl-Meyer Scores were recorded at the time of Stroke Unit Admission by the OT unaware of (RULT) score results. Statistical analyses were performed using SPSS version 11 and significance was attributed if p<0.05 using 2-tailed analyses.

Results:
A total of 88 patients (39 F/49 M) admitted to an inpatient stroke rehabilitation unit a mean of 15 days post stroke were referred for (RULT). Participants had a mean of 4 ± 2.7 SD treatments each. Two withdrew due to pain in the affected upper limb, and 2 due to depression/frustration. The remaining 84 participants expressed approval of (RULT), and the volunteer considered their personal involvement in the program as worthwhile and meaningful. Admission MIT-Manus data provided by the Adaptive-3 treatment software showed that the Normalized Jerk+Line+Target (Norm JLT) Score [defined as (Jerk Score/237)+(Deviation from a Straight Line/13)+(Target Distance Error/14)] demonstrated a significant Spearman-rho Correlation with admission Functional Independence Measure (FIM) upper dressing r = -.346 p=.001; lower dressing -.229 p=.037, FIM grooming subscores r = -.435, p=.000, and Fugl-Meyer Upper Limb Score -.326, p=.007. The Norm JLT score also predicted change in FIM Lower Dressing -.444, p=.000, Change in FIM Grooming -.260, p=.018, and change in Fugl-Meyer Upper Limb scores from admission to discharge r = -.491, p = 0.000.

Conclusions:
Robotic Upper Limb Therapy by a trained Volunteer on an inpatient Stroke Rehabilitation Unit is easily administered, viewed by both patients and volunteer as rewarding, and provides objective measures useful for assessing upper limb function and outcome.
Brain-computer interfaces are often used for control, rehabilitation, research, spelling, but an emerging application is an assessment of patients with disorders of consciousness (DOC). DOC patients have varying levels of cognitive activity, with categories such as vegetative state (VS) and minimally conscious state (MCS). For the physician or family members, it is difficult to know which cognitive functions are left. But it is crucial to learn whether patients can understand conversations or can even communicate.

The current study a UWS patient was assessed if he is able to communicate. The system works with (i) vibrotactile P300 with 2 tactors and (ii) vibrotactile with 3 tactors. In both (i) and (ii), oddball paradigms are presented to the patient for 2.5 minutes, and the patient has to actively count either deviant auditory stimuli or deviant vibrotactile stimuli. In (ii), the patient has one tactor on the left hand, one tactor on the right hand and one on a neutral midline location. The person has to count either the stimuli on the left or right hand to produce a corresponding P300 response. Then, the evoked potentials are calculated and statistically analysed. Additionally, brain-computer interface (BCI) algorithms are trained on the data to provide an objective measure of classification accuracy. In the next step, questions can be asked to the patient, who can answer by counting the stimuli on the right hand to say YES and on the left hand to say NO. In the current study, the patient was assessed with the VT2 and VT3 paradigm and achieved in both cases 100% accuracy. Based on this data the system was calibrated and 20 questions were asked to the patient. 15 were answered correctly, 1 was wrong and 4 were undetermined.

The system can assess DOC patients and help us understand if they can do standard cognitive tasks. The classification accuracy is an objective marker to understand whether the patient can follow conversations and even communicate with the environment.
A BCI detects the neuronal activity of patients’ motor intention and controls external devices to provide appropriate sensory feedback via the peripheral nervous system to central nervous system (CNS). When the feedback is timely sent to CNS according to the motor intention with multiple training sessions, the neuronal network in the brain is reorganised due to the neuroplasticity. In this current study, a BCI controlled an avatar and functional electrical stimulation (FES) to provide the visual and proprioceptive feedback respectively. The expected task was to imagine either left or right wrist dorsiflexion according to the instructions in randomised sequences. Then, the linear discriminant analysis and common spatial filter classified the brain activity acquired by EEG. The avatar and FES were triggered only upon correct classification. The avatar of forearms was presented to patients in the first-person point of view, and FES produced a smooth passive dorsiflexion of the patient’s wrist. The training was designed to have 25 sessions (240 trials of either left or right motor imagery) of BCI feedback sessions over 13 weeks. Two days before and two days after the BCI training intervention, five clinical measures were used to observe any motor improvement. The primary measure was upper extremity Fugl Meyer assessment (UE-FMA) which evaluates the motor impairment. Four secondary measures were also performed to exam the spasm (modified Ashworth scale, MAS), tremor (Fahn tremor rating scale, FTRS), the level of daily activity (Barthel Index, BI), and finger dexterity (9 hole peg test, 9HPT). One male stroke patient (53 years old, 11 months since stroke onset, and paralysis in his right upper limb) participated in the training. He quickly learned to use the BCI system and the average of maximal classification accuracy was over 90% after the 5th session. The UE-FMA jumped from 25 to 46 points after the intervention and his behavioural improvement was also detected in the secondary measures. The BI increased from 90 to 95 points, meaning that he could be more independent in his daily activity. MAS and FTRS decreased from 2 to 1 and from 4 to 3 points respectively, implying less spasticity and tremor in his hand. Although he could not conduct the 9HPT until 18th training session, he was able to complete the test from the 19th session in 10 mins 22 secs and the time was reduced to 2 mins 53 secs after 25th session. The system is currently validated with 10 validation partners in Japan, USA, Austria, Spain and China and a group study with 50 patients including a control group with only FES will be finished soon.
T21: Spatial Stepping Measures Improve Following Overground Locomotor Training in Adults with Incomplete Spinal Cord Injuries

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Background:
Following an incomplete spinal cord injury (iSCI), locomotor stability is commonly diminished due to impaired control of one’s center of mass (COM). As a compensatory mechanism, people with neurological injuries, including iSCI, often walk with increased stride width and decreased stride length when compared to unimpaired individuals. It is critical that individuals with iSCI safely and efficiently control their COM when navigating the environment. Overground locomotor training (OLT) may serve to improve spatial gait characteristics in people with iSCI. Changes in stride width (SW) and stride length (SL) while walking at varying speeds may indicate improved dynamic stability in people with iSCI, leading to increased movement function and higher quality of life.

Purpose:
To determine changes in SW and SL during overground walking at slow (SWS), preferred (PWS), and fast (FWS) speeds in adults with incomplete spinal cord injuries following a novel 12-week OLT program.

Methods:
Five subjects with motor iSCI (4M/1F; age 38.4±17.11 years; ASIA C and D) walked on a pressure-sensitive walkway at a self-determined slow, preferred, and fast walking speed prior to (PRE), and following (POST) completion of a 12-week OLT intervention. The intervention comprised of participants attending two 90-minute sessions per week that included uniplanar and multiplanar part-to-whole tasks. Participants walked with his/her preferred assistive device at each speed. A paired t-test was used to determine significance (α = 0.05) between pre- and post-intervention assessments of group means for stride width and length.

Results:
At the PRE assessment, SW during SWS was 11.47±5.93cm; 10.95±7.03cm at the PWS, and 11.16±8.05cm at the FWS. SL during the PRE assessment was 68.65±11.35cm for SWS; PWS was 75.65±13.31cm and FWS was 88.95±20.64cm. SW significantly decreased for all speeds at the POST assessment (SWS: 9.59±5.14, p=0.0007; PWS: 8.71±6.35, p=0.0026; FWS: 8.36±5.93, p=0.0017). SL increased following OLT for all speeds (SWS: 79.31±10.05; PWS: 96.81±16.39; FWS: 108.92±21.84; p<0.0001).

Conclusions:
Adults with iSCI demonstrated increased locomotor stability after 12 weeks of an OLT intervention. Decreased SW and increased SL indicates improved control of the center of mass within the base of support during overground stepping at varying speeds.
Transcranial magnetic stimulation (TMS) is a commonly used for assessing or modulating brain excitability. However, small deviations in coil placement can greatly alter testing outcomes. Navigated TMS systems can address this issue, but most systems are too costly for use in clinical and research environments. Here, we developed a low-cost solution for navigated TMS, and tested this system during standard TMS procedures. The system we developed uses a low-cost 3D camera system (OptiTrack Trio), which communicates with our free and open source software environment programmed using the Unity 3D gaming engine. The environment is user friendly and has functions to allow for a variety of stimulation procedures (e.g., head and coil co-registration, multiple hotspot/grid tracking, intuitive matching, and data logging). The system was then validated using static mock-up and live TMS sessions, where we measured errors associated with the system and collected motor evoked potential (MEP) recruitment curves from human subjects, respectively. During the static mock-up experiment, we found that the system reliably placed the coil within 1.0 ± 0.06 mm and 0.51° ± 0.46° of the desired displacement and orientation. During live TMS sessions, we found that the system improved coil placement accuracy, and improved the reliability (ICC > .95) and quality of MEPs obtained between sessions when compared with non-navigated TMS. These results indicate that the system is a viable tool for reliable coil placement during TMS procedures, and can improve accuracy in locating the coil over a desired hotspot both within and between sessions. Future iterations should allow for integration of subject-specific magnetic resonance images (MRI) for tracking of the coil relative to brain geography.
Growing numbers of randomized clinical trials in neurorehabilitation are suggesting that any given therapy has a range of responders and nonresponders. One recommendation is a more individualized approach to motor-based therapy in which patient characteristics such as age, cognitive status, disease severity, brain health, etc. could be used to differentiate between responders and nonresponders. We have recently reported that within patients diagnosed with amnestic Mild Cognitive Impairment, the ability to learn a functional motor task is related to performance on a battery of visuospatial tests. The purpose of this study was to test whether these findings generalized to a sample of 24 age-matched older adults with no memory impairment. All participants were assessed with the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS), from which age-adjusted scores for five cognitive domains were extracted. Participants’ baseline performance on a motor task designed to improve upper extremity motor function was also measured prior to a short (9-trial) practice session; motor performance was re-assessed one week later. Motor performance was quantified as the time to complete a given trial of the task, with faster times indicating better performance. Stepwise regression indicated that the visuospatial/constructional index of the RBANS was the only cognitive domain that significantly predicted one-week follow-up motor performance ($R^2=0.24; \ p=0.04$) once baseline performance was accounted for. As the visuospatial/constructional index is comprised of a line orientation subtest and a complex figure copying subtest, further regression analysis indicated that the line orientation scores were most related to the amount of improvement at one week ($p=0.02$). These findings are consistent with prior work showing that visuospatial tests may be used prognostically to identify motor learning deficits in older adults, irrespective of any other memory impairments. These affordable, readily-available tests are quick, easy to administer, and are standardized against large normative datasets, making them ideal for clinical use as predictors of individualized responsiveness to rehabilitation. Future directions will explore the underlying neural mechanism of why visuospatial tests appear to uniquely capture the aging brain’s motor learning capacity.
Short-interval intracortical inhibition (SICI) is a commonly used paired-pulse transcranial magnetic stimulation (TMS) measure to assess inhibition in the motor cortex and for monitoring changes in corticomotor excitability after an intervention. Typically, SICI is measured at rest, as active contraction is known to reduce the inhibitory effects. While resting MEPs can be elicited without much discomfort in upper-extremity muscles, it is often difficult to elicit (without causing discomfort) in lower-extremity muscles, such as the quadriceps femoris. Further, the magnitude of SICI could vary based on the interstimulus interval (ISI), conditioning stimulus intensity (CSI) and test stimulus intensity (TSI), which have not been fully characterized for the quadriceps muscle during active contraction. Thus, this study aimed to determine the optimal stimulation parameters for measuring SICI in the quadriceps muscle group during active contraction. We tested 17 healthy adults over a range of CSIs (70, 80, and 90%), TSIs (100, 110, 120, 130, and 140% AMT), and ISIs (1.0, 1.5, 2.0, 2.5, and 3.0ms). SICI was quantified using both torque and EMG (i.e., MEP) responses. Results demonstrated that 70% CSI at 1ms ISI produced the greatest inhibition for all TSI. Further, comparison of all CSIs demonstrated that 70% CSI produced the greatest inhibition, whereas 90% CSI produced the least inhibition for both torque and EMG responses. In general, inhibitory effects were confounded by facilitatory effects at 100% TSI. It was also found that as CSI increased, greater TSI was required to achieve inhibition when using torque as an output measure. Our findings indicate that a CSI of 70%, ISI of 1ms, and TSI > 110% are ideal for measuring SICI in the quadriceps muscle during active contraction.
Cognitive screening may improve clinicians’ ability to predict patients’ responsiveness to motor rehabilitation. We have demonstrated in adults over 65 with and without significant memory deficits (i.e., Mild Cognitive Impairment) that lower scores on standardized visuospatial tests like line orientation and complex figure copy are associated with less retention of a motor skill. These tests, however, can take tens of minutes to complete, and are typically administered as part of a much longer and comprehensive neuropsychological battery. Thus, the purpose of this study was to determine whether a briefer cognitive screening tool could predict motor skill retention as well. To do so, data from 36 adults aged 43 to 94 with no diagnosis of Mild Cognitive Impairment were retrospectively analyzed. Cognitive status was tested with the Montreal Cognitive Assessment (MoCA), which is very brief (2=0.12; \( p = 0.04 \)). For reference, the Visuospatial/Executive subtest is scored from 0-5, and includes trail making, drawing the face of a clock from memory, and copying a simple drawing of a cube. The participant with the most retention (47% improvement 24 hours later) had a score of 5, whereas the participant with the least retention (19% worse 24 hours later) had a score of 2. The unique relationship between this MoCA subtest and skill retention is highly consistent with our previous findings from a different cognitive assessment altogether. Collectively, our findings suggest that cognitive screening for motor rehabilitation should focus on the visuospatial domain. Future studies are needed to determine which visuospatial tests/abilities are most predictive of skill retention in older adults.
T26: Aligning of Anatomy and Electrophysiology in the Rat Internal Capsule Reveals Somatotopical Organization and Enables Targeted Lesions

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The relationship between nervous system anatomy and physiology is critical to understanding function in health and adaptation after injury. While laboratory animals allow detailed examination of anatomy with tracers and electrophysiology with invasive electrodes, two main issues currently limit comparison of the two methods. First, histological methods shrink tissue and can section the brain in slightly different planes. In addition, aligning anatomy and physiology onto common coordinates can be challenging. To overcome the differences that arise from processing tissue for histology, we developed software we call Tissue Morph that matches histological sections to a brain atlas (Paxinos), similar to aligning human brain imaging onto a common template. In addition, we created separate software called Brain Map that allows alignment and visualization of anatomy and physiology maps of individual animals onto a common coordinate system and then combination of groups of animals. Analysis of 10 rats indicate variability of tissue sectioning and shrinkage. Tissue Morph reduced the variability and enabled better alignment between animals. There was also a mismatch between maps of the internal capsule obtained from physiology and histology; this mismatch was reduced after morphing of the anatomy. Comparison of anatomy and physiology with Brain Map revealed strong somatotopy of the rat internal capsule. We used this map to lesion the forelimb representation of the internal capsule with photothrombosis using an optrode. Alignment of lesions onto the common space with anatomy and physiology showed accurate and selective targeting of the forelimb fibers of the corticospinal tract. This was confirmed with loss of axons labeled by tracer injections into the forelimb area of motor cortex. In conclusion, this new method allows accurate reconstruction and overlay of anatomical and physiological maps that enable selective lesion of the forelimb area of the internal capsule.
Background:
Corticospinal tract (CST) integrity is strongly linked to motor function. Recent work in children with unilateral cerebral palsy (UCP) due to perinatal brain lesions shows that asymmetry in CST integrity is also a predictor of functional improvement following intensive motor training regimens, such as constraint-induced movement training (CIMT).

Objective:
To determine the association between corticospinal tract integrity and motor function improvement following a combined tDCS and CIMT intervention in children with UCP as assessed through diffusion imaging and transcranial magnetic stimulation (TMS).

Methods:
Twenty children with UCP were scanned prior to a 10 day intervention, consisting of 20 minutes of simultaneous contralesional cathodal tDCS and CIMT, followed by 100 additional minutes of CIMT only. Structural (T1-weighted, 1 mm isotropic), motor task-based fMRI (2 mm³ resolution, TR=0.8 s, MB = 8) and a pair of diffusion MRI scans (1.5 mm³ resolution, MB=3, 46 volumes each with b-value =1000 and 2000 s/mm², 7 non-diffusion weighted volumes, AP and PA phase encode) sequences were acquired. Probabilistic tractography of the CSTs was performed using a manually-drawn brainstem ROI (start seed) and a motor cortex ROI derived from the task-based fMRI activation map (termination seed). A laterality index (LI=[ipsilesional-contralesional]/(ipsilesional+contralesional)] was computed for the diffusion metrics of CST volume and weighted fractional anisotropy (FA). CST integrity was also characterized based on presence or absence of ipsilesional motor evoked potentials (MEP) using TMS. Correlations between LI, baseline motor function and change in motor outcomes (Assisting Hand Assessment—AHA and more-affected hand grip strength) were performed.

Results:
Nine children (45%) were excluded from analysis (7 missing diffusion and/or task-fMRI scans, 1 poor registration, and 1 poor image quality). CST volume LI was associated with baseline AHA (r=0.77, p<0.01) and grip strength (r=0.80, p<0.01), but was not related to change in motor function following the intervention. FA LI was not significantly associated with baseline AHA (r=0.48, p=0.13) or grip strength (r=0.34, p=0.31), and did not significantly correlate with change in motor function following the intervention. Improvement in the AHA following the intervention was greater in children with an ipsilesional MEP (n=7, 10.1±4.4 AHA units) compared to children without an ipsilesional MEP (n=4, 5.0±0.82 AHA units). Furthermore, FA LI was greater, and thus more symmetric, in children with an ipsilesional MEP (n=7, -0.01 ± 0.08) compared to children without an ipsilesional MEP (n=4, -0.06 ± 0.04).

Conclusions:
Diffusion imaging measures of CST integrity were not clearly associated with improvement following a behavioral and neuromodulatory intervention in children with UCP. TMS assessment of CST integrity showed that the presence of an ipsilesional MEP was related to greater improvement in motor function. Multimodal assessment of CST integrity provides complementary information regarding motor function following behavioral intervention.
Background:
Right-hemisphere (RH) strokes have worse long-term outcomes than left-hemisphere (LH) strokes, even though language and dominant hand are mostly affected by the latter (Ween et al., 1996). This implicates cognitive impairments that are worse after RH stroke. Hemispatial neglect (hemineglect) is much more common after RH than LH lesions (Stone et al., 1993) and receives a great deal of clinical and research attention. However, while common in acute stroke, persistent hemineglect is comparatively rare (Cassidy et al., 1998) and unlikely to explain fully the worse outcomes of RH stroke survivors.

Objective:
By assessing cognitive functions attributed to the RH and exploring their neural basis using functional MRI (fMRI) in RH stroke survivors (>5 months post-stroke), we investigate which cognitive impairments may affect long-term outcomes after RH stroke and consider how they could be treated.

Methods:
Here we present a growing dataset on visual-spatial impairments and functional brain reorganization in participants with chronic RH stroke (n=10 at submission; a larger sample will be presented). Hemineglect was assessed using the NIHSS (Brott et al., 1989) and the BIT (Wilson et al., 1987); other visual-spatial skills were assessed using the ROCF (Rey, 1941) (reproducing a line drawing of nested geometric figures) and the WASI-II Block Design (Wechsler, 2011). Participants also completed a line bisection fMRI task that elicits strongly right-lateralized parietal activation in neurologically healthy participants.

Results:
Our behavioral data demonstrate that RH stroke survivors have deficits in visual-spatial skills that persist months after stroke. Even though only 3 of 10 patients had hemineglect, Block Design scores fell at least 1 std below normal in all, contrasting sharply with normal or above-average Vocabulary scores. ROCF reproductions were disorganized; only 2 stroke survivors began with the central rectangle (a common approach taken by neurologically healthy people that indicates good organization of the figure into its constituent geometry).

Our fMRI data for the line bisection task reveal left parietal activations (homotopic to the normal right parietal activation for this task) in RH stroke survivors with and without HN. This parallels findings of homotopic RH activation during language tasks in LH stroke survivors with aphasia (Turkeltaub et al., 2011).

Conclusions:
This growing dataset illustrates the importance of looking beyond hemineglect when diagnosing and treating RH stroke. Complex spatial tasks reveal deficits even in the absence of hemineglect. Since these deficits persist in the chronic phase, they may contribute to disability even if they are not as obvious in everyday interactions as hemineglect or aphasia. The fMRI data also suggest a potential avenue for treatment: augmenting rehabilitation with non-invasive neurostimulation by suppressing or enhancing the homotopic activations, depending on whether they prove beneficial or detrimental to functional recovery.
T29: Stepping Intensity During Overground Training Influences Gait Speed in People with Incomplete Spinal Cord Injury: A Case Series

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Introduction:
The 10-meter walk test (10MWT) is a commonly used measure for gait assessment in individuals with incomplete spinal cord injury (iSCI). Although gait speed is commonly measured pre- and post-intervention, stepping intensity during training is often subjectively measured via participant feedback. The relationship between objective data on training intensity and overground gait speed following participation in a novel overground locomotor training (OLT) program has not been established and may provide insight regarding participants’ response to OLT interventions.

Objective:
To explore the influence of stepping intensity during overground locomotor training sessions on preferred and maximal gait speeds in adults with iSCI.

Methods:
Three subjects with motor iSCI (2M/1F; ages 20, 48, and 48; ASIA C and D) completed 10MWT. Assessments were conducted before (PRE) and after (POST) a 12-week training cycle that included two 90-minute sessions per week of OLT. At the PRE assessment, all individuals completed 10MWT using an assistive device (AD). At the POST assessment one participant could only ambulate with AD, one participant performed with and without an AD (AD preferred), and one participant no longer used an AD. Stepping intensity was determined over 5+ training sessions per participant by StepWatch™ Activity Monitor (Washington, DC). Stepping intensity was categorized by StepWatch™ Activity Monitor software as percentage of steps per session categorized as low or medium stepping intensity.

Results:
Participant 1 (AD only) increased preferred gait speed 53.3% [0.17 to 0.26 m/s] and maximal gait speed 26.7% [0.25 to 0.32 m/s]. Participant 2 completed PRE and POST testing both with and without an AD. With an AD, preferred gait speed increased 10.8% [0.44 to 0.49 m/s] and maximal gait speed increased 6.0% [0.65 to 0.69 m/s]. Without an AD, Participant 2 increased preferred gait speed 6.4% [0.40 to 0.43 m/s] and maximal gait speed 20.3% [0.48 to 0.57 m/s]. Participant 3 transitioned to walking with no AD at the POST, with preferred gait speed increasing 168% [0.30 to 0.81 m/s] and maximal gait speed 235% [0.40 to 1.32 m/s] without an AD. Stepping intensities measured during the intervention period were consistent for Participant 1 (13% to 7% of steps medium stepping intensity), decreased for Participant 2 (67% to 41% of steps medium stepping intensity), and increased for Participant 3 (35% to 82% of steps medium stepping intensity).

Conclusions:
The 12-week OLT improved preferred and maximal gait speeds in all participants. Individuals training with consistent or increasing stepping intensity demonstrated greater gains in preferred and maximal gait speeds than the individual whose stepping intensity decreased over the duration of the intervention. This suggests utilizing objective measures of training intensity may be valuable to optimize training session intensity for gains in overground ambulation for individuals with iSCI.
Achieving proper muscle activation patterns necessary for functional tasks is extremely challenging for stroke survivors with severe hand impairment. Deficits are often apparent in the abilities to fully activate a muscle, to deactivate a muscle, to modulate muscle activation with tasks, and to alter the overall muscle activation with task. To encourage exploration and expansion of this limited muscle activation workspace, we developed a custom computer game that is electromyographically (EMG)-controlled. Specifically, principal components (PCs) describing the accessible regions of the EMG activation workspace are mapped to the axes of the computer screen, with one PC representing the vertical direction and one PC representing the horizontal direction. The user must create scaled combinations of these EMG patterns to move the cursor to play games such as revealing a picture, navigating a maze, or avoiding asteroids. Users played games 9-35 min per session for 8-9 sessions spread over 6 weeks. Over the sessions, the PCs for the ipsilesional (less impaired) hand were gradually introduced as the target PCs for the contralesional (more impaired) hand. In this manner, subjects were encouraged to change their activation patterns. To date, 8 stroke survivors with severe, chronic hemiparesis of the hand (rated Stage 2 or Stage 3 of the Stage of Hand section of the Chedoke-McMaster Stroke Assessment scale) have completed this training. EMG recordings from four upper extremity muscles of the contralesional hand (flexor digitorum superficialis, flexor carpi radialis, extensor digitorum communis, and extensor carpi ulnaris) were analyzed to find the 4-dimensional volume of the activation workspace encompassing the EMG signals. Preliminary results show that the activation workspace enlarged, on average across subjects, by 48% from the first to the last game session (paired t-test \( p = 0.04 \)). The time to complete the picture revealing game also shortened by approximately 2 minutes on average. The finding suggests that the activation workspace can be altered, even in stroke survivors with severe, chronic hemiparesis. The use of this EMG-controlled game, which could be readily implemented in the clinic, may prove to be a beneficial and inexpensive rehabilitation tool for a subpopulation currently faced with limited resources.
Unilateral brain injury in adults often leads to hemisphere-specific impairments. Language is dramatically affected by left-hemisphere (LH), but not right-hemisphere (RH) lesions. In the visual-spatial domain, adults with LH injury have difficulty representing the details of a spatial pattern, while adults with RH injury have difficulty integrating constituent parts into a coherent whole. In contrast, the effects of early brain injury are often less dramatic and less hemisphere-specific. After early LH injury, the RH can support near-normal language proficiency. However, spatial processing may show subtle deficits even after early injury (Akshoomoff et al., 2002); it is unclear whether these deficits are hemisphere-specific. We explore these questions by testing adolescents and adults who had a perinatal stroke on a complex spatial task: the Rey-Osterrieth Complex Figure (ROCF) (Osterrieth, 1944; Rey, 1941).

Participants were 14 individuals who had a unilateral brain injury at birth, resulting from a stroke to the middle cerebral artery (Mean age at test = 20.55 yrs, SD = 3.78 yrs, Range = 16.33–26.75 yrs). Five individuals had RH lesions; nine had LH lesions. Fourteen healthy controls were also tested. Participants were instructed to copy the ROCF exactly (Copy condition), and then draw it from memory (Immediate Recall condition). Both product (the final drawing) and process (the steps by which the figure was drawn) were assessed.

The Boston Qualitative Coding System (Stern et al., 1994) was used to score the completed drawings (product). A score was given for each of three types of elements: Configural, Cluster, and Detail. In the Copy condition, patients and controls produced drawings that were quite similar. In the Immediate Recall condition, patients had significantly lower Configural, Cluster, and Detail scores, regardless of lesion site. Based on the adult literature, one might have predicted that RH patients would more often omit Configural (global) elements while LH patients would omit Detail (local) elements, but no group differences were found.

The drawing process was characterized by order of construction: Perimeter (outer contour first), Partial Perimeter (portion of the outer contour), and Nonperimeter (internal elements first) (Akshoomoff & Stiles, 1995). When drawing from memory, all healthy controls followed a Perimeter process, which better organizes the drawing and has been linked to higher accuracy (Shorr et al., 1992). In contrast, only 3 patients followed a Perimeter process. Again, no differences were found between the LH and RH groups.

These results highlight deficits in both product and process of visual-spatial performance that are affected by perinatal stroke. Notably, individuals who have had a LH or RH perinatal stroke show similar overall deficits and no apparent qualitative differences on this task. Thus visual-spatial impairments following early stroke persist into adulthood and are characterized by a surprising degree of qualitative similarity.

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Purpose:
Atypical movement control strategies in the brain are required for recovery of motor function after stroke. Recruitment of non-pyramidal corticospinal tracts is one of these strategies. We explored the relationship between changes in motor function and structural integrity in both pyramidal and non-pyramidal alternative motor tracts following intensive motor learning therapy.

Methods:
Nine stroke survivors (>6 months post-stroke) with arm sensorimotor deficits had 12-week (5 d/week, 5 hr/day) or 300hrs of motor learning therapy. Outcome measures included Arm Motor Ability test (functional domain) and Diffusion Tensor Imaging (DTI). The DTI tensor was fit using FSL software and the fractional anisotropy (FA), axial diffusivity (AD), and radial diffusivity (RD) were computed at each image voxel. After transforming to the MNI template (and left-right reversing those with right hemisphere lesions) the average FA, AD, and RD were computed in canonical templates that corresponded to the pyramidal tracts (PT) and alternative motor tracts (aMT) on both sides of the brain below any region affected by lesions. We performed Spearman correlation to evaluate the relationship between AMAT and DTI measures. Bonferonni correction for multiple comparisons was used in consideration for statistical significance.

Wilcoxon paired sign rank test was used to compare pre vs post rehab scores for AMAT.

Results:
Subjects were 56±4.9 years old, 4.2±2.5 years after stroke and 55% were female. AMAT score improved from 2.34±0.79 to 2.88±1.0 (p=0.0039, paired sign rank test). In response to rehabilitation and only in the aMT, improved AMAT score correlated with increased both ipsilesional AD (rho=0.84, p=0.006) and RD (rho=0.88, p=0.003); and a trend of correlation was observed between decreased FA in ipsilesional aMT and improved motor function (rho=−.72, p=0.03). Greater response to therapy correlated with higher FA in ipsilesional aMT at baseline (rho=0.83, p=0.009) but only a trend for the ipsilesional PT at baseline (rho=0.69, p=0.04). For the contralesional tracts, only a trend of correlation was observed in the aMT where increased RD with improved AMAT score (rho=0.71, p=0.038).

Conclusion:
Remodeling of alternative non-pyramidal motor tract may play a more important role than remodeling of pyramidal tracts in improvement of motor function following intensive upper limb motor learning therapy in chronic stroke.
Background:
Removing barriers to post-stroke rehabilitation care is critical to ensuring survivors reach their highest level of functioning. Selecting and adopting easily disseminated telehealth technology that can be utilized in the home environment is an important consideration in the delivery of remote rehabilitative care. The Department of Veteran Affairs’ (VA) My HealtheVet (MHV) web-based patient portal provides secure access to personal health information and has a secure messaging feature for online communication with the VA health care team. The usability of the VA MHV web-based patient portal to facilitate rehabilitative care has not been explored. This study investigates the utility of the VA’s secure messaging system and MHV patient portal for tele-rehabilitation in chronic stroke. This study will determine whether home tele-rehabilitation is equivalent to clinic-based rehabilitation for recovery of arm use in Veterans with chronic upper extremity stroke deficits. If this aim is met, the VA would be able to expand the continuum of stroke care from the clinic to the home with an evidenced-based tele-rehabilitation prototype.

Methods:
Approvals were received to pilot the use of MHV secure messaging, for research purposes, as current VA policies limits use to clinical purposes. Participants in the tele-rehabilitation intervention received a premium MHV account to access secure messaging, and educational resources. Each participant completed clinic-based MHV training; were prescribed a bilateral arm exercise device (Tailwind™) and functionally-based arm exercise training (transition to task training (TTT)) program to be performed three sessions per week at home. Participants communicated with the therapist using MHV secure messaging to communicate daily completion status, exercise monitoring, and individualized prescription updates via links to YouTube.

Results:
Reported preliminary outcomes will include travel and mileage saved using the tele-rehabilitation platform, number of secure messages exchanged, and qualitative benefit of the tele-rehabilitation and secure messaging platforms using patient satisfaction surveys. This tele-rehabilitation format will be compared to a control group completing training in the traditional clinical setting with direct provider interaction.

Conclusion:
The feasibility of this approach for post-stroke upper extremity rehabilitation has implications for tele-rehabilitation of neurological motor deficits throughout the Veteran’s Health Administration. This platform has potential for nationwide use and development for other neurological diseases.
Arm weight support (WS) can mitigate upper limb impairment after stroke but its neurophysiological basis is not well understood. We investigated muscle activity, corticomotor excitability (CME), and muscle synergy expression in 13 chronic stroke patients and 6 age-similar healthy controls under three levels of WS: low = 0, medium = 50, and high = 100 % of full support. Impairment was assessed with the Fugl-Meyer upper extremity scale, with patients categorised as having either mild or moderate-severe impairment. Surface electromyography (EMG) was recorded from 8 muscles spanning the forearm, upper arm and shoulder. Muscle synergies were evaluated using a non-negative matrix factorisation technique from EMG data obtained during reaching movements made to an array of 14 targets with the paretic (or dominant control) arm. Overall, greater WS resulted in lower EMG levels, but the degree of modulation between WS levels was less evident for patients with moderate-severe compared to mild impairment. Healthy controls exhibited a larger number of synergies than patients with moderate-severe impairment and more synergies were evident with high compared to low WS. Transcranial magnetic stimulation was used to elicit motor-evoked potentials (MEPs) in muscles of the paretic arm during static arm abduction. Stimulus-response curves were fitted to MEP area data using nonlinear regression to provide measures of CME. The effect of WS on CME varied between distal versus proximal muscles and with impairment severity. In summary, WS reduces muscle activity and modulates CME in a manner which may reinstate intrinsic muscle synergies and offset chronic upper limb impairment.
Timely and accurate clinical decision-making in stroke rehabilitation is crucial given the rising costs of care and declining hospital and inpatient rehabilitation facility (IRF) stays. In current stroke rehabilitation practice, behavioral-based assessments primarily drive clinical decision-making, but these measurements are only a rough approximation of patients’ underlying physiological brain state. Neuroimaging provides unique insights about stroke-induced changes in brain state and, thus, may improve the precision of clinical decision-making. The purpose of this ongoing study was to determine the association between motor recovery and electroencephalography (EEG)-based measurements of brain function in patients with subacute stroke admitted to an IRF.

Based on prior work, we hypothesized that EEG measurements of power and coherence in delta (1-3 Hz), beta1 (13-19 Hz), and beta2 (20-30 Hz) frequency bands from electrodes overlying ipsilesional and contralesional primary motor areas (iM1 and cM1, respectively) and secondary motor regions (supplementary motor area (SMA) and dorsal premotor area (PMd)) would significantly predict subsequent changes in Functional Independence Measurement (FIM)-motor and Upper Extremity Fugl-Meyer (UEFM) scores across the IRF admission. Twenty patients (4 females, age 57.8±13.6 years, 14.8±14.4 days post-stroke) completed testing that included motor behavior and a three-minute resting-state EEG. In contrast to our hypothesis, functional EEG measurements did not relate to changes in FIM-motor and UEFM scores \( (p<0.05) \). However, when patients were split into two groups based on their baseline motor impairment status, relationships between brain function and motor recovery emerged.

For patients with baseline UEFM scores <40 points \( (n=7) \), FIM-motor score improvement correlated significantly to baseline delta coherence between iM1 and cM1 \( (r_s=0.81, p=0.026) \) along with relative delta power in iM1 \( (r_s=0.79, p=0.033) \) and iPMd \( (r_s=0.81, p=0.026) \). UEFM score improvement related to relative delta power in cPMd \( (r_s=0.83, p=0.04) \). For patients with baseline UEFM scores ≥40 points \( (n=13) \), FIM-motor score improvement correlated significantly with beta1 coherence between iM1 and cM1 \( (r_s=0.66, p=0.014) \) and relative beta1 power in iM1 \( (r_s=0.58, p=0.04) \). UEFM score change significantly related to relative beta1 power in iM1 \( (r_s=0.76, p=0.029) \) and bilateral PMd regions \( (r_s=0.73-0.79, p=0.018-0.38) \) and was inversely correlated to delta coherence between iM1 and SMA \( (r_s=-0.78, p=0.02) \) along with relative delta power in cM1 \( (r_s=-0.80, p=0.018) \). Motor impairment groups did not differ by lesion volume, corticospinal tract (CST) integrity, or CST/lesion overlap.

These findings provide preliminary support for the utility of EEG-based biomarkers of motor recovery potential and their application in an IRF setting. Motor recovery and brain function associations specific to a patient’s motor impairment level reinforce the value of patient stratification when assessing biomarker performance.
Background:
Persistent pain is common following stroke, yet evidence for effective treatments targeting persistent pain for people who experience stroke is poor. In recent years an educational strategy involving pain neuroscience has been utilised with success in other populations with complex persistent pain. We are not currently aware of any evidence regarding the use of pain neuroscience education for people who experience stroke with persistent pain. In order to develop an optimal educational strategy, it is important to advance our current understanding of pain beliefs and perceptions in people who experience persistent pain following stroke to adequately address their needs.

Aims:
We aimed to characterise beliefs and perceptions of people who experience stroke with persistent pain, and compare those to a non-stroke population with persistent pain. We also aimed to identify the perceived cause of persistent pain in both populations.

Method:
An online survey of a Pain Beliefs and Perceptions Inventory for stroke and non-stroke populations with persistent pain. Participants were eligible if they reported experiencing persistent pain over the past 3 months, were over 18 years of age and able to provide consent. Participants rated their pain severity on a numerical pain scale and nominated their perceived cause of pain. The Pain Beliefs and Perceptions Inventory included 16 statements, with Likert Scale ratings, across the following domains: Mystery; Permanence; Constancy and Self-blame. Pain beliefs and perceptions regarding the pain experience were characterised and compared across the two groups using Mann Whitney U test.

Results:
A total of 218 participants (107 stroke and 111 non-stroke) completed all questions. The stroke group reported higher pain severity than the non-stroke group, and identified the stroke itself as the primary cause of their pain, rather than a body injury. People who experience stroke with persistent pain demonstrated significant differences across all 4 domains (mystery, permanence, constancy and self-blame) of the Pain Beliefs and Perceptions Inventory, when compared to the non-stroke population. There was a strong belief in the stroke group that their pain is constant and permanent. In reporting high mystery scores, the stroke group imply the absence of an explained cause of their pain, and this can potentially be associated with feelings of threat of future harm.

Conclusion:
Findings of this online study reflect a poor understanding of persistent pain following stroke for the participating population. Novel insights from these results should be considered in the development of a tailored educational program for stroke survivors with pain, which can be included as part of therapy for people who experience stroke.
T38: Quantifying Activity Participation in the First Year After Stroke: Trajectory of Participation Outcomes Across International Stroke Cohorts from Australia and the Netherlands.

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**Background:**
The World Health Organisation identifies participation as a valued outcome; yet relatively little is known about the activities engaged in and trajectory of participation outcomes post-stroke.

**Aim:**
To compare the course of participation outcomes in the first year post-stroke in international cohorts, using quantitative measures of participation that detail the actual activities engaged in. Specifically we undertook to map the activities that patients re-engage in during the first year post-stroke, relative to prior activities.

**Methods.**
Participation outcomes were characterized and compared between the START stroke cohort (an Australian prospective longitudinal cohort of 200 stroke survivors that includes 98 with participation data) and the Restore4Stroke cohort (a Dutch prospective longitudinal cohort study including 395 stroke patients). Participation was measured directly after stroke, at 2-3 months and 12 months post-stroke. Cohorts were characterised and compared for background demographics, and for the level of participation (% retained activities), using the Activity Card Sort (ACS) for the Australian cohort and the Utrecht Scale for Evaluation of Rehabilitation–Participation (USER-P) for the Dutch cohort. As the ACS includes cards with specific activities, it was adapted to the items of the USER-P, allowing pooling of data across common domains and activities.

**Results.**
Ninety-one patients were available for analyses for the START cohort, and 218 for the Restore4Stroke cohort. Preliminary analyses, without significance testing, showed that the two cohorts were similar for the following variables: age at stroke ($x_{\text{START}} = 65.5$ vs. $x_{\text{Restore4stroke}} = 64.8$ years), percentage males (68% vs. 67%) and NIHSS score 2/3days post-stroke ($x_{\text{START}} = 2.0$ vs. $x_{\text{Restore4stroke}} = 2.3$). The START cohort showed a slightly lower percentage with high education level (20% vs. 27%) and having a partner (72% vs. 76%). The START cohort comprised ischemic stroke only (100%) whereas in Restore4Stroke, 94% of the patients had ischemic stroke. The ACS was adapted to the items of the USER-P, thereby creating common participation-items and restriction-items. Participation-items were used to derive percentage retained activities and restriction-items to examine the proportion of patients actually performing the activities post-stroke. A mean of 90% of activities were retained for the START (SD=16%) and Restore4stroke (SD=27%) cohorts at 2-3 months post-stroke across vocational, household, leisure and social activities. At 12 months post-stroke START participants retained a mean of 95% of activities (SD=12%), while those in Restore4stroke retained 99% (SD=26%).

**Discussion and conclusion.**
Stroke survivors with mild stroke severity in Australia and the Netherlands retained a high proportion of pre-stroke activities at 2-3 months and at 12 months post-stroke. Investigation of the frequency of participation in retained activities is recommended. More detailed comparison of participation outcomes using quantitative measures such as the ACS and the USER-P is indicated.
Objective/Purpose:
To date, single voxel spectroscopy (SVS) is the most commonly used magnetic resonance spectroscopy (MRS) technique. SVS is relatively easy to use and provides automated and immediate access to the resulting spectra. However, it is also limited in spatial resolution. A new and very promising MRS technique allows for whole-brain MR spectroscopic imaging (WB-MRSI) with much improved spatial resolution. Establishing the reliability of data obtained using the two techniques is an important first step for using them to evaluate longitudinal changes in metabolite concentration. The purpose of the present study was to assess and directly compare the reliability of metabolite quantification at 3T using SVS and WB-MRSI in bilateral ‘hand-knob’ areas of motor cortices in healthy volunteers.

Methods:
Ten healthy adults were scanned using both SVS and WB-MRSI on three occasions one week apart. N-acetyl-aspartate (NAA), creatine (Cr), choline (Cho) and myo-inositol (mI) were quantified using SVS and WB-MRSI with reference to both Cr and H2O. The reproducibility of each technique was evaluated using coefficient of variation (CV), and the correlation between the two techniques was assessed using Pearson correlation analysis.

Results:
A total of 60 SVS scans (2 voxels x 3 sessions x 10 subjects), and 30 WB-MRSI scans (3 sessions x 10 subjects) were collected. The measured mean (range) intra-subject CVs for SVS were 4.79 (2.65-6.60)% for metabolites (i.e., NAA, Cho, mI) relative to Cr, and 6.26 (4.21- 8.88)% for metabolites (NAA, Cr, Cho, mI) relative to H2O. The mean (range) CVs for WB-MRSI were 6.09 (2.78-11.04)% for metabolites relative to Cr, and 5.98 (4.57-9.50)% for metabolites relative to H2O. Significant positive correlations (Pearson’s r ranging from 0.6-0.9) were observed between metabolites quantified using SVS and WB-MRSI techniques when the Cr but not H2O reference was used.

Conclusion:
The results from this study demonstrate that for both SVS and WB-MRSI, there is good reliability and comparable reproducibility for quantifying the four major metabolites (NAA, Cr, Cho, mI). Our findings add reference information for choosing the appropriate 1H- MRS technique in future studies.

Keywords:
magnetic resonance spectroscopy, single voxel spectroscopy, whole-brain magnetic resonance spectroscopy, metabolite, reproducibility

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Disclosure of Interests:
The authors have no conflicts of interest to disclose.
T42: Age-related Declines in Generalization of Motor Skill Learning: Implications for Task-Specific Training in Older Patients

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Task-specific training may be used as an upper extremity neurorehabilitative approach involving repetitive practice of a functional motor skill. Unfortunately, time and resources limit how many tasks can be practiced during treatment; thus, the benefits of practicing one task must generalize in order for this to be a viable neurorehabilitative approach. Given the growing number of older patients within neurorehabilitation, identifying whether the aging brain can generalize motor skill learning is critical. Thus, the purpose of this study was to test whether older adults would generalize learned information between two functional tasks. Based on proof-of-concept findings in younger adults, we hypothesized that after extensive task-specific training, participants would show improved performance on a different motor task, whereas participants with no training would not. Seventy-three adults age 65 years and older (mean 75.2±6.98 yrs) with no self-reported neurological diagnosis participated in this study. Cognitive status was measured using the Montreal Cognitive Assessment (MoCA). All participants were tested at baseline on a functional dexterity task involving fastening buttons with their nondominant hand. Participants were randomly assigned to a training (n=35) or control (n=38) group. The training group repetitively practiced a different functional motor task involving spooning beans from point to point, similar to the simulated feeding subtest of Jebsen Hand Function Test, for a total of 2,250 repetitions over three days. They were then re-tested on the functional dexterity task, and compared to baseline. The control group had no task-specific training, and were re-tested three days later on the dexterity task. The training group improved on the task they trained on (see Schaefer et al., 2015), but contrary to our hypothesis, they did not show significantly more generalization than the control group overall (p=0.82). Within-group regression analysis revealed that younger participants (ages 65-74) who underwent task-specific training showed significant generalization (95% CI [2.42, 15.23]), but with a decrease of one percentage point per year of advancing age. Interference emerged at age 75, such that functional dexterity was worse at re-test. Adding middle-aged adults (ages 40-64, n=17) to the sample did not change the regression slope (p=0.87). Generalization was also not related to participants’ total MoCA scores (p=0.32). Results suggest that task-specific training may not be beneficial for older patients in neurorehabilitation, given the potential for interference. Future studies are needed to determine whether there are optimal doses of task-specific training that maximize learning while minimizing interference in older patients.
T44: First-trial Protective Step Performance Before and After Short-Term Perturbation Practice in People with Parkinson’s Disease

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Background:
Protective postural responses to loss-of-balance, including protective stepping, are critical to prevent falls. Previous work indicates that perturbation training, which consists of repeated exposure to external balance perturbations, can reduce the risk of falling, with effects lasting up to 12 months. People with Parkinson’s disease (PD) also benefit from perturbation training. However, these studies often report average performance over several trials at the beginning and end of training. Performance on the first trial is particularly important from a clinical perspective, as falls in daily life are due to a single loss-of-balance event. Further, recent work suggests performance on the first trial may be different from subsequent trials given the startling nature of postural perturbations. Thus the aim of this study is to determine the effect of short-term perturbation training on first trial reactions in people with Parkinson’s disease.

Methods:
13 people with PD and 9 healthy adults completed 2 laboratory visits on consecutive days. All participants were naïve to support surface perturbations. Day 1 consisted first of an initial “backward” perturbation (9cm; 18cm/s), in which the ground moved forward underfoot, requiring a backward protective step. Then, participants underwent 10 medio-lateral perturbations. Finally, they underwent 25 forward and 25 backward perturbations, pseudo-randomly ordered. On day 2, participants returned to the laboratory and again completed the initial backward perturbation. Our primary outcome variable was margin of stability (MOS) at first foot contact after the first perturbation on day 1 compared to the first perturbation on day 2. Secondary outcome variables included step length, step latency, and EMG onset.

Results:
Mixed-model repeated measure ANOVAs showed that first-trial protective stepping performance was improved on day 2 (i.e. after practice) compared to before practice for MOS (f1,20=13.16; p=0.002), as well as step length (f1,20=5.82; p=0.026). Step latency and muscle onset showed non-significant improvements from day1 to day 2 (f1,20=4.17; p=0.055 and f1,30=4.00; p=0.055; respectively). No group by time interactions were observed.

Conclusion:
Previous results show that people with PD improve protective stepping through short-term perturbation training. The current results extend these findings, demonstrating that performance of the first protective step is also improved. These data are similar to previous findings in healthy older and younger adults demonstrating that short-term exposure to perturbations can result in improved performance on loss-of-balance scenarios.
T46: Effects of Short-Term Perturbation Practice on First-Trial Protective Stepping Performance in People with Multiple Sclerosis and Unimpaired Controls

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Background:
Perturbation training is effective at improving protective postural responses in healthy and neurological populations. However, these investigations typically explore the average protective stepping performance over multiple trials. Perturbation-related falls in clinical populations, such as people with multiple sclerosis (MS), commonly occur in response to the first episode of loss of balance.

Purpose/Hypothesis:
To determine whether persons with MS or unimpaired age-matched adults demonstrate improved performance on the first exposure to support surface perturbations before and after short-term perturbation practice. We hypothesized that persons with MS (1) can improve first-trial protective stepping performance through short-term perturbation practice, and (2) improvements in first-trial stepping performance will be less pronounced in people with MS than controls.

Methods:
Six people with MS (age 56.6+/−8.6yrs; 57% male) and six healthy-matched peers (age 56.1+/−7.2yrs; 57% male) completed two laboratory visits on consecutive days. On day 1, protective stepping performance was assessed via a treadmill-based support surface perturbation in which the ground moved forward underfoot. The trapezoidal perturbation waveform consisted of a 300ms 1.25m/s² acceleration, followed by 500ms constant velocity, and finally 300ms deceleration (1.25m/s²) to rest. All trials resulted in a protective step in the backward direction. Participants then underwent 35 trials of perturbation practice at 1.5m/s² (25 backward step, 10 forward step, pseudo-randomly ordered). On day two, participants returned to the laboratory where we reassessed backward protective stepping with another single 1.25m/s² acceleration perturbation. The primary outcome was margin of stability (MOS), defined as the distance between the base of support and center of mass at the end of the first step. MOS of the first trial on day 1 (before practice) and day 2 (after practice) were compared. Larger MOS represents a more effective protective steps. Statistical comparisons included independent or paired-sample t-tests as appropriate.

Results:
Data collection is ongoing. Preliminary analyses show that MS demonstrated worse (i.e. smaller) MOS compared to healthy adults (p=0.034). Both groups showed non-significant trends toward improved MOS between day 1 and day 2 (Control- Day1: 0.19+/−0.09, Day2=0.26+/−0.05: p=0.084; MS- Day1: 0.11+/−0.09, Day2=0.14+/−0.09; p=0.199). Improvement from day1 to day2 were not different between groups (p=0.67).

Discussion:
Similarly to previous results, people with MS exhibited altered protective postural responses compared to healthy adults. First trial-responses were not significantly improved in either group after a short-term perturbation practice given the small sample and variable responses that are typical of this outcome. Data do however suggest a trend toward improvement in both groups (Cohen’s d effect sizes of MS and healthy adults= 0.60 and 0.89, respectively). Further data collection is warranted and a larger cohort will lead to a better understanding of the influence perturbation practice on first-trial protective responses. Given the clinical relevance of first-trial protective stepping responses, clinical evaluations & future studies should attend to performance on first trials in addition to ensemble averages.
T47: Use of PedBot Robotic Rehabilitation: Neurophysiologic Measures of Motor Training in a Pediatric Population

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Background and Objective:
Robotic rehabilitation strategies have been found to substantially improve functional recovery in stroke patients. The effectiveness of this approach in pediatric rehabilitation is still not clear. Recently, we have developed a robotic rehabilitation system, PedBot, which could supplement current therapy methods for ankle rehabilitation. The PedBot robot consists of three intersecting axes and includes a 6 DOF force/torque sensor. The patient sits on a therapy chair (Rifton Medical Incorporated) with the foot immobilized in the device. A video game based on an airplane motif has been developed, controlled by patient’s foot and with adjustable level of the difficulty.

The objectives of this study are: to assess feasibility of using PedBot for leg training in children; to determine if differences in patterns of muscle activation between subjects and controls can be identified by surface electromyography (EMG) recording during performance of a standard game-sequence; to determine if motor training induces EMG patterns (agonist-antagonist activation) changes.

Methods:
Children age 5-17 with chronic stroke or spastic cerebral palsy (CP) and healthy controls were enrolled in this IRB-approved study. Subjects sat in the PedBot with foot in the support and knee positioned at 90 degrees. Wireless EMG sensors were positioned on anterior tibialis-AT (channel 1), long peroneus-LP (channel 2), medial gastrocnemius-MG (channel 3), and lateral gastrocnemius-LG (channel 4) muscles, and EMG was recorded during performance of a simple game-trial involving ankle flexion/extension, pre- and post- training. Training involved 10 one-minute game-sequences.

EMG analog signals were digitized at 1925 Hz with EMGworks acquisition software (DelSys Inc., Boston, MA) and bandpass filtered, with a range of 25–500 Hz. Agonist/antagonist muscle activation at each time-point was recorded. Linear regression analysis was used to establish the relationship between the absolute value of the EMG signal (mV) and robot/foot position (degrees) at each time.

Results:
9 controls and 3 subjects were enrolled. One subject was unable to complete un-assisted trials and was excluded. A pattern of co-activation of agonist/antagonist muscles was demonstrated in patients but not in controls. Brief training induced changes in EMG patterns, suggesting reduction in antagonist activation. In controls, average regression slope (degrees/mV) changed before and after training from 0.26 to 0.3 for AT, from -0.04 to -0.14 for MG, and from -0.1 to -0.15 for LG, demonstrating improved performance. In subjects, gastrocnemius performance improved after training (from -0.05 to -0.1 for MG and -0.04 to -0.27 for LG, respectively). Decreased EMG signal was recorded from AT after training, possible related to fatigue.

Conclusion:
PedBot-supported training has a potential to improve muscle performance in pediatric patients and to restore EMG patterns similar to healthy subjects. More data is necessary to confirm these preliminary findings, and to determine the duration and functional significance of this effect.
Background:
Repeat injections of botulinum toxin A (BoNT-A) are often necessary to maintain clinical benefit in patients being treated for spasticity. The recommended minimum interval between injections is 12 weeks; however, a longer duration of therapeutic benefit is of potential clinical and socio-economic interest. We aimed to evaluate the time to retreatment following an injection of abobotulinumtoxinA (Dysport®) in three populations with spasticity: Adult Upper Limb Spasticity (AULS), Adult Lower Limb Spasticity (ALLS), and Pediatric Lower Limb Spasticity (PLLS).

Design:
Data was obtained from three Phase-III trials of abobotulinumtoxinA (one per indication). The two adult studies recruited hemiparetic patients (post-stroke/TBI) with upper limb (n=243) and lower limb (n=381) spasticity, respectively. The pediatric study recruited children (2-17 years old) with dynamic equinus foot deformity due to cerebral palsy (n=241). All three studies implemented a flexible time to re-treatment design whereby investigators decided (based on their clinical judgment of safety and efficacy) whether the individual patient required re-injection at Week 12 (mandatory visit) then to optional visits Week 16 (all studies), Weeks 20 & 24 (adult studies), or Weeks 22 & 28 (pediatric study) of the treatment cycle. Once the patient completed the double-blind study (i.e. once they required retreatment), they advanced to the open-label extension study where they could receive up to 4 repeat treatment cycles.

Results:
A substantial proportion of patients in each of the three studies had a time to retreatment that exceeded the usual 12-week interval. In the AULS study, 37% of patients did not require re-treatment until Week-16 or later (17% at Week-16, 10% at Week-20, 10% at Week-24 or later). In the ALLS study, 20% of patients were re-injected at Week-16 or later (10% at Week-16, 5% at Week-20, 5% at Week-24 or later). In the PLLS study, 74% of patients were reinjected at Week-16 or later (34% at Week-16, 23% at Week-22, 18% at Week-28 or later). Safety results were consistent with previous experience.

Conclusions:
These data indicate that a substantial proportion of adult and pediatric patients treated for spasticity with abobotulinumtoxinA do not require reinjection at the ‘standard’ time-point of 12-weeks. A long time to re-treatment with abobotulinumtoxinA may be helpful in reducing the social and economic burden associated with repeat injections. For example, in patients receiving regular repeated BoNT-A treatments, extending the interval from 12 weeks to 16 weeks could mean one less injection per year.

Funding:
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T49: AbobotulinumtoxinA Injections in Patients with Upper and Lower Limb Spastic Paresis and Impaired Function Following Stroke or Traumatic Brain Injury

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Background and Objectives:
Management of spastic paresis often requires both upper (UL) and lower limb (LL) treatment. The American Academy of Neurology 2016 practice guideline update recommended abobotulinumtoxinA (Dysport®, aboBoNT-A) as a Level A treatment, signifying that effectiveness has been established and intervention should be offered, for both UL and LL spasticity. However, limited data exist investigating simultaneous treatment of both UL and LL with botulinum toxin type A. This post hoc analysis evaluates walking speed (WS) in hemiparetic patients administered aboBoNT-A in both UL and LL simultaneously.

Methods:
Phase-III, open-label (OL) study (NCT01251367) performed at 52 centers (11 countries) worldwide. Eligible patients had previously completed the double-blind (DB) placebo-controlled study (NCT01249404). DB study patients received aboBoNT-A 1000 U or 1500 U in the LL for one treatment cycle (TC). The OL study consisted of repeated injections (≤4 TCs performed at ≥12 weeks apart) over ≤18 months. Patients received aboBoNT-A 1500 U in LL for TC1 and TC2; from TC3, patients could receive ≤500 U in the UL (total dose ≤1500 U). Here we report 10-meter comfortable barefoot WS for patients at TC3 and TC4.

Results:
Of the 352 patients enrolled, 63 received co-injection in LL and UL at both TC3 and TC4, and 64 received injection in the LL only. Mean (standard deviation, SD) aboBoNT-A doses in the LL at TC3 and TC4 were 1380 U (210) and 1360 U (220), respectively, in patients receiving LL injection only; and 1000 U (50) and 1000 U (50), respectively, in patients injected in LL+UL.

At baseline, 10-meter comfortable barefoot WS (mean [SD]) was similar in patients injected in LL+UL (0.42 [0.20] m/s) compared with LL only (0.42 [0.20] m/s). At TC3 Week 4, both subgroups showed improvements from baseline (mean change [SD]: LL+UL: 0.063 [0.131] m/s; LL only: 0.078 [0.114] m/s), which further improved to TC4 Week 4 (LL+UL: 0.086 [0.166] m/s; LL only: 0.086 [0.123] m/s). AboBoNT-A exhibited a safety profile consistent with previous clinical experience.

Conclusions:
In patients with spastic paresis requiring concurrent treatment of the LL and UL, it was possible to split the 1500-U total dose of aboBoNT-A between both extremities, while still improving WS at a similar rate to that observed in patients injected in lower extremities only. These results provide important information for the simultaneous treatment of the LL and UL with aboBoNT-A in adult patients with hemiparesis.
In the United States an acute stroke occurs every 45 seconds, resulting in over 800,000 new strokes every year to make it the leading cause of long-term disability. Many survivors of stroke experience significant limitations in mobility. In addition to pure motor deficits in the lower limb, individuals with hemiparesis face added challenges in negotiating common environmental constraints, such as avoiding obstacles. Meeting these challenges requires sufficient attentional and planning capacity to monitor gait in order to adapt as needed. Because stroke is known to adversely affect cognitive function, there may be a more complex interaction between underlying motor impairments and increased cognitive effort while walking. To probe this possibility, we used high-density electroencephalography (EEG) to compare real-time changes in cognitive attentional load while standing quietly vs. precision treadmill walking in subjects with hemiparetic stroke and nondisabled subjects. For the precision walking condition subjects were instructed to avoid stepping on white lines spaced approximately two meters apart, walking at their preferred speed. Both conditions lasted two minutes.

Subjects with chronic hemiparesis (n=7) and non-disabled controls (n=7) were measured with 64-channel EEG while performing counter-ordered tasks: 1) quiet standing with eyes open and 2) steady-state precision walking task (periodic avoidance of white lines affixed to the treadmill belt). In each condition the magnitude of coherence (i.e. networking) to the motor-planning region (Fz) from distributed scalp topography (Frontal, Central, Temporal, Parietal, and Occipital) was derived using amplitude coherence in the low-beta band (13 – 20 Hz).

The statistical analysis was a 2 (Group) X 2 (Hemisphere) X 5 (Region) mixed design ANOVA, which revealed a Group X Condition interaction, F(1,12) = 8.13, p = .015). Thus, the cortical dynamics during precision walking vs. quiet stance indicated a significantly increased EEG coherence, reflecting greater neural cost associated with walking in individuals with stroke when compared to non-disabled controls. Additionally, coherence measures during quiet standing did not differ between groups, nor was there a significant difference between the standing and walking conditions in the nondisabled group.

These results suggest that for persons with hemiparetic stroke, walking with a minimal low-risk challenge imposes a significant increase in motor-planning network activity compared to quiet standing. In contrast, nondisabled subjects showed undifferentiated network efficiency during both conditions. For stroke survivors this reduced efficiency reflects an increased cognitive burden associated with ambulation, an issue that warrants further study to understand its impact on optimal mobility rehabilitation.
Background:
Aerobic exercise is known to promote neuroplastic responses in the healthy and injured brain. Although the role of exercise in ALS is still debated, there is some evidence to suggest that moderate intensity exercise programs can improve function and may reduce disease progression. Exercise induced improvements may be mediated by enhancing neurobiological changes within the motor cortex (M1) via modulation of cortical excitability and upregulation of neuroprotective factors. However, the neurophysiologic effects of exercise on brain function in individuals with ALS are still unknown. Here, we sought to investigate the safety and feasibility of recumbent stepping as an intervention to possibly facilitate neuroplasticity, and slow disease progression in individuals with ALS.

Objective:
To determine the effects of a 4-week moderate intensity, recumbent stepping program on lower limb motor cortex excitability, disease progression and motor function in individuals with ALS.

Participants:
7 ambulatory participants with a diagnosis of clinically probable, or definite ALS (mean ALSFRS-R = 33.16 ± 7.13) were recruited for this study.

Intervention:
Participants performed moderate intensity exercise (40 – 60% Heart Rate Max) for twelve sessions (3 times a week/4 weeks), with the NuStep ergometer (total time – 40 minutes, 5 minutes warm up and cool down each).

Outcome Measure(s):
Neurophysiological outcomes included recruitment curves of TMS-induced (Transcranial Magnetic Stimulation) motor evoked potentials of the tibialis anterior muscles. Clinical outcomes included ALS Functional Rating Scale Revised (ALSFRS-R), 10 meter walk test (10MWT), 6 minute walk distance (6MWD), Timed up and Go test (TUG), Fatigue Severity Scale (FSS), Beck Depression Inventory (BDI) and quality of life as measured by SF-12. Measurements were collected at baseline and 4-weeks post intervention.

Results:
6 participants completed the trial without any adverse issues. One participant dropped out due to an ankle fracture unrelated to exercise. Motor evoked potentials were present only in 2 participants, and showed a trend towards increased excitability (13 – 17%) from baseline. There was a 7 % improvement in gait speed that was statistically significant (P = 0.046). Changes in 6MWD and TUG showed a trend towards improvement (12- 16 % change; P > 0.05). ALSFRS-R, SF 12, BDI and FSS did not show any change with exercise.

Conclusion:
Results from this preliminary study supports that recumbent stepping is a safe and feasible exercise intervention in individuals with ALS, resulting in significant improvements in gait speed. However we could not completely evaluate the effects of recumbent stepping on neuroplasticity as 4 participants did not have any responses to TMS even at the highest tolerable intensity. Future studies will examine the neuroplastic and behavioral effects of exercise in a larger cohort of participants.

Keywords:
aerobic exercise, corticomotor excitability, amyotrophic lateral sclerosis, ALSFRS-R, recumbent stepping, neuroplasticity
Hypothesis/Purpose:
Progress in understanding recovery and assessing the impact of rehabilitation post-stroke has been limited by the lack of good measures of motor function. Despite being a widely used scale, the FMA-UE has several limitations related to scoring, reliability and validity. Hand grip dynamometry has been found to be an important assessment tool for multiple purposes in clinical practice. While grip strength potentially offers advantages for assessment of motor impairment and recovery post-stroke, there is a need to contextualize grip strength measurements, and differences between hands following stroke. Most research studies use the raw scores of maximal voluntary contraction (MVC) while studying grip strength. However, there are different approaches to express MVC values which have the potential to provide greater context for grip measurements, improving their sensitivity and better explaining their relationship to clinical measures, if any. The main aims of this study were: 1) To understand how grip strength relates to the most commonly used gold standard UE stroke assessment scale, 2) To determine the best way to calculate and understand grip strength variation between hands post-stroke.

Number of subjects:
We evaluated a cohort of 115 participants (Mean age: 64 ±12 yrs, 23 women, mean FMA: 35 ±23 points, mean chronicity: 56 ±62 months).

Materials/Methods:
Age matched norms for each hand and sex were calculated based on the classic reference data published by Mathiowetz. These MVC values were further analyzed using 3 approaches 1) MVC difference between hands 2) MVC ratio 3) Laterality ratio. Rasch analysis was used to convert the FMA-UE into an interval scale with the goal of improving the sensitivity of the scale and potentially making each score more meaningful.

Results:
Rasch analysis improved the sensitivity of FMA-UE. The MVC ratio revealed itself to be the most sensitive technique of evaluating the change in grip strength.

Conclusions:
True to our hypothesis, differences in raw MVC scores between hands showed a moderate correlation to FMA-UE. The MVC ratio formulae showed a stronger correlation explaining 70-80% of the variance. These results seem encouraging with the measure being straightforward and time efficient.

Clinical Relevance:
This study indicates the importance of contextualizing the raw MVC scores. Providing an appropriate context for strength measurements could help better understand the prognosis pattern in post-stroke individuals. Rasch analysis has the potential to better understand the FMA scores by converting it into an interval scale and to detect the post-stroke individuals who do not fit into the scale and contaminate the sample with error. The MVC laterality ratio has the potential to be used as an outcome measure post-stroke.
Gamma-aminobutyric acid (GABA) is the main inhibitory neurotransmitter within primary motor cortex (M1) and plays a critical role in shaping motor output and the induction of neural plasticity. After stroke, GABAergic inhibition is altered which can persist into the chronic stage (> 6 months). However, due to the heterogeneity of stroke, it can be difficult to quantify GABA-mediated inhibition in some patients due to reduced or absent corticomotor output. The aim of the present study was to investigate GABA concentration and neurotransmission within ipsilesional and contralesional M1 using novel neurophysiological and neuroimaging techniques. Twelve chronic stroke patients (mean time post stroke = 60 months, range: 8-180 months) and 16 age-similar controls were recruited for the study. Upper limb impairment was assessed with the Fugl-Meyer Upper Extremity Scale (mean [out of 66] = 48, range: 11-65) and function with the Action Research Arm Test (mean [out of 57] = 37, range: 3-57). Magnetic resonance spectroscopy (MRS) was used to obtain M1 GABA concentrations. Threshold tracking paired-pulse transcranial magnetic stimulation (TMS) protocols were used to examine short- and long-interval intracortical inhibition (SICI, LICI) and late cortical disinhibition (LCD). MRS indicated that GABA concentration is reduced within ipsilesional (0.076 ± 0.010, \( P = 0.009 \)) and contralesional (0.080 ± 0.009, \( P = 0.024 \)) M1 compared to controls (0.114 ± 0.008). Threshold tracking TMS indicated that LICI is greater in ipsilesional M1 (31.17 ± 3.81%) compared to controls (10.71 ± 1.73%, \( P < 0.001 \)) and contralesional M1 (20.04 ± 3.58%, \( P = 0.049 \)). In contrast, LCD is reduced in ipsilesional M1 (8.98 ± 5.80%) compared to controls (-4.75 ± 2.39%, \( P = 0.028 \)). No differences in SICI at 1 or 3 ms were observed between patients and controls (both \( P > 0.107 \)). There was a negative association between LCD and Fugl-Meyer scores (\( \rho = -0.86, P = 0.002 \)) and LCD and Action Research Arm Test scores (\( \rho = -0.73, P = 0.017 \)), where patients with more disinhibition exhibited less impairment and greater function. MRS and threshold tracking paired-pulse TMS may offer advantages for assessing GABA concentration and neurotransmission after stroke, which is relevant for studies attempting to improve functional outcomes through GABA-mediated processes.
T54: Asymmetric Property of Ankle Stiffness Predicts Balance Capability in the Elderly with Chronic Post-stroke Hemiparesis

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Introduction
The elderly with post-stroke hemiparesis has asymmetric lower-limb musculoskeletal characteristics that cause balance impairments (Turnbull et al, 1996). Previous studies have shown that the rehabilitation therapies of the paretic ankle joint, one of two major strategic balance contributors, improved postural sway and symmetry during gait and balance recovery activities (Cheng et al., 2001; Yavuzer et al. 2006). Asseldonk et al found that chronic hemiparetic patients had asymmetric contribution mechanism of paretic and non-paretic ankle joints during bilateral standing in response to sway (2006). However, little is known about the relationship between asymmetric ankle properties and clinical balance capability in the elderly with post-stroke hemiparesis. The purpose of this study was to investigate whether the ankle stiffness asymmetry between paretic and non-paretic sides has relationship with the weight distribution during bilateral standing, and then predicts the balance capability in the elderly with chronic post-stroke hemiparesis.

Methods
Total 13 elderly with chronic post-hemiparesis (F:3, M:10, Age: 65.3±9.3yrs, Duration: 10.1±6.1yrs) participated in clinical trials. A custom Ankle Movement Trainer (AMT) was developed to provide the non-weight-bearing bidirectional isokinetic passive ankle movements during which the ankle stiffness was evaluated. While a subject was seated with 90 degree knee flexed, a target paretic or non-paretic foot was fastened onto the see-saw type foot cradle in AMT and moving along two anatomical ankle axes, talocrural (dorsi- and plantarflexion) and subtalar (inversion/eversion) axes, respectively. The ankle stiffness symmetry ratio (ASSR) was calculated by the ratio between paretic and non-paretic sides of the total range of center of pressure trajectory on the AMT during mediolateral or anteroposterior isokinetic passive ankle movements. The primary outcomes are ASSR, the mediolateral ratio of weight distribution during bilateral standing (Bilateral Standing Symmetry Ratio (BSSR)), which was measured during standing on two bilateral force plates comfortably with eyes open and closed, and the Berg Balance Scale (BBS). The Pearson linear correlation coefficient was assessed between ASSR and BSSR. BBS was then predicted by ASSR and BSSR using multiple regression.

Results
The BSSRML has a significant correlation with mediolateral ASSR and (Eyes open: r=.641, p= 0.018; eyes closed: r=.725, p=.005). BBS has a significant correlation with anteroposterior ASSR (r=-.556, p=0.048). The multiple regression model predicted BBS by ASSR alone (r2=.600, p=0.01), and both BSSR and ASSR (r2=.784, p=0.002).

Conclusion
Asymmetric properties of ankle stiffness successfully predicted the clinical balance capability in the elderly with chronic post-stroke hemiparesis. The bidirectional isokinetic passive ankle movements were useful to estimate the paretic and non-paretic ankle stiffness. Besides, further study investigates the relationship between ASSRML and BSSRML considering both weight-bearing bilateral standing and non-weight-bearing ankle movements in AMT.
Introduction:
Post-stroke sensory deficits exacerbate motor deficits and hamper motor recovery after stroke. Application of sensory afferent stimulation for 1-2 hours immediately prior to hand motor task practice has been shown to increase hand motor function more than hand task practice alone. This study examined whether sensory stimulation applied concurrently during hand task practice can yield similar benefits, thereby reducing the time burden on patients. The sensory stimulation used was subthreshold (imperceptible) random-frequency wrist skin vibration, since this stimulation can be applied during hand motor tasks without interfering with hand use and it has been shown to immediately improve sensation and motor function in chronic stroke survivors while it is on, in previous studies. While the overall study investigated the effect of this sensory stimulation on clinical hand function and neural plasticity, this paper focuses on the neural plasticity assessed by electroencephalography (EEG).

Methods:
A pilot, double-blinded randomized controlled trial. Fourteen chronic stroke survivors (>6 months post stroke) were enrolled (n=6 treatment, n=7 control, n=1 withdrew before randomization). All subjects practiced functional motor tasks using the paretic hand for 2 hours per session, for a total of 6 sessions, with a vibrotactile device on the wrist. The control group received no vibration, and the treatment group received subthreshold vibration. Evaluation was performed before and after the 6-session task practice. Evaluation included cortical activity for repeated paretic hand grips assessed by EEG. EEG data was analyzed in EEGLAB. Artifacts were removed following independent component analysis and data was epoched relative to grip events. Changes in the baseline power prior to grips and the grip-event related spectral perturbation (ERSP) in the alpha and beta frequency bands for the sensorimotor areas (channels C3/C4) were compared between groups.

Results:
The baseline alpha power decreased bilaterally pre to post intervention for the treatment group, while it did not for the control group (p<.05). Changes in the other EEG measures did not significantly differ between groups.

Discussion:
The result suggests that application of imperceptible vibration during hand motor task practice may lead to change in cortical activity. The alpha baseline power reduction may be related to increased attention to hand sensorimotor tasks.
Several studies have examined changes in neural networks resulting from stroke and subsequent motor deficits. However, the evidence to date is contradictory due to methodological heterogeneity, small sample sizes, and lack of multimodality corroboration of findings in each subject. Here, we aim to measure differences in brain network recovery using induced neural oscillatory activity of motor evoked potentials utilizing multiple imaging modalities (rsMEG, tbMEG, fMRI, HARDI) in stroke subjects before and after receiving MindMotionPRO (MMPRO) rehabilitation. MMPRO is a virtual reality-based rehabilitation system designed to enhance upper limb motor function in the post-stroke setting. The proposed study will be the first longitudinal, multi-modality examination of functional and structural brain connectivity and their relationship to clinical measures of motor function during the acute stages of recovery. We aim to enroll 12 subjects after a first-ever stroke in the anterior or middle cerebral artery territory who have a Fugl-Meyer Assessment of Upper Extremity (FMA-UE) of <40 and motor evoked potentials in the lesioned hemisphere within 10 days of the stroke. Exclusion criteria include age<18, inability to communicate, pain limiting rehabilitation dose, seizure disorder, dementia (as estimated by MMSE <18), depression, or moderate to severe hemispatial neglect. All subjects will receive standard of care over three weeks, along with MMPRO for 1000 minutes over three weeks, 6 times/week (roughly 60 minutes daily). All other therapies will be unchanged. Each subject will have MEG and fMRI in the acute stroke setting (while hospitalized, T1), and four weeks after the stroke (T2). T1 and T2 will also include a full functional assessment (FMA-UE, streamlined Wolf Motor Function Test, and mRS). At 3-4 months post-stroke (T3), each subject will again go through the same function-testing battery, though no imaging will be performed at this time point. We hypothesize that 1) the MMPRO-treated subjects will show improved network connectivity (measured by induced neural oscillatory activity with tbMEG), 2) MMPRO-treated subjects will exhibit increased network activity in the primary and secondary motor networks in the perilesional cortex positively correlating with functional motor scores, and 3) temporal variations in the onset of MEG activity in the ipsilesional and contralesional primary and secondary motor areas during affected upper extremity movement will predict recovery. Together, this study will allow us to identify the brain network connectivity changes following MMPRO intervention after stroke and correlate those changes to motor function recovery. In addition, it will help determine the prognostic value of acute imaging of motor network characteristics for predicting motor function recovery.
T57: Use of the Microsoft Kinect 2 to Stratify Fall Risk in Stroke Survivors

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Introduction:
Falls are the leading cause of medical complications for stroke survivors across the post-stroke lifespan. In other clinical populations, risk assessment and stratification initiatives are known to decrease the incidence of falls. Being able to assess fall risk in stroke survivors is essential if they are to live safely and independently, however, many experience challenges accessing the current service delivery model (i.e. regular clinic appointments). Use of telemedicine principles can provide an effective solution for meeting these challenges. The Microsoft Kinect 2 (MK2) is a low-cost motion capture device that continuously tracks up to 25 anatomical locations, allowing for full-body motion capture in real-time. The MK2 outputs reliable and valid data that can be used to quantify a variety of movement impairments when used appropriately. There is a critical need for a new generation of tools to quantify balance ability and fall-risk in stroke survivors safely, accurately and cheaply in a home environment.

Methods:
Stroke survivors and age-matched, community-dwelling seniors with no history of stroke (control cohort) were recruited and instructed to perform a sequence of six, simple postural stability tasks whilst in a seated position. The movement sequence was performed with subjects positioned in front of a MK2 sensor, allowing us to track movement kinematics during task performance. In addition, each participant performed assessment items on the Berg Balance Scale (BBS) so as to acquire a clinical gold standard for each subject’s balance ability. We then applied a novel machine-learning paradigm to the MK2 data in order to determine the extent to which data from the MK2 could be used to reliably classify healthy seniors from stroke survivors.

Results:
We recruited 15 stroke survivors and 29 age-matched controls to participate in the trial. The BBS scores for the stroke survivor cohort was 37 (±12) (mean±standard deviation), while age-matched controls showed significantly higher scores (52±2; p<0.01, rank-sum test). Data collected from the MK2 as subjects performed the six seated tasks was analyzed with our novel machine learning paradigm in order to determine whether the MK2 data could be used to differentiate between stroke survivors and controls. Using area under the curve (AUC) as a metric, where a score of 1 is considered “perfect”, we showed near-perfect accuracy for discriminating the two groups using any of the six tasks (0.9±0.05), and tasks 3 and 5 showed the best accuracy (0.965±0.007). These results were significant (p<0.001; permutation test)

Conclusions:
We have developed a process that uses low-cost motion capture technology, and a short balance assessment process to accurately classify between individuals who are at-risk of falling compared with those who are not. This is an exciting step in creating scalable fall prevention processes that allow at-risk seniors to receive services that will help avoid fall-related health complications.
T58: Acute High-Intensity Exercise and Locomotor Adaptation after Stroke

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Background/Objective:
Stroke impairs retention of a novel locomotor task. Recent evidence suggests that an acute high-intensity exercise bout coupled with motor practice may improve motor learning and retention in neurologically intact adults and therefore could be potentially implemented to improve learning post-stroke. We investigated the effect of an acute high-intensity exercise bout on retention of a locomotor adaptation task (split-belt treadmill) post-stroke. We hypothesized that greater retention would be observed in the exercise groups compared to the control group.

Methods:
34 chronic stroke survivors participated in two sessions 24 hours apart. Subjects were allocated to the active control group (CON; N=11) or one of two exercise groups: treadmill walking (TMW; N=12), and total body exercise on a cycle ergometer (TBE; N=11). All groups exercised for a short bout (~5 minutes) before (CON and TMW) or after (TBE) split-belt locomotor adaptation in session 1. The CON group walked slowly on the treadmill (25% of fast walking speed; FWS) whereas the TMW and TBE groups exercised at high intensity (70-85% age-predicted maximal heart rate). In session 1, the task was to walk on a split-belt treadmill in a 2:1 speed ratio (100 and 50% FWS) for 15 minutes, during which a new step length symmetry pattern should be learned. In session 2, subjects repeated split-belt treadmill walking as a test of retention. The primary outcome was step length symmetry change related to retention of learning from session 1 to 2: magnitude of retention (mean initial 10 strides session 1 –session 2) and learning rate (% total strides to reach plateau in step length symmetry session 1 - session 2). We also calculated the magnitude of adaptation during session 1 (mean initial 10 strides – mean last 30 strides) to determine whether differences in retention could be due to differences in adaptation. To test the exercise effect on learning, we compared adaptation, retention and learning rate among groups (CON, TMW, TBE) using one-way ANOVA or Kruskal-Wallis test.

Results:
All groups adapted similarly on session 1 (p=0.847); however, neither exercise group showed greater magnitude of retention (p=0.801) or learning rate compared to CON (p=0.09, p=0.34, TMW, TBE, respectively).

Conclusions:
Similar to our recent report in healthy adults, present findings suggest that an acute high-intensity exercise bout coupled with a locomotor adaptation task does not influence retention of what was learned from one session to another in those post-stroke. This is in contrast to previous work in healthy adults showing that exercise has a positive influence on retention of a newly learned motor skill. Together these results suggest that a short high-intensity exercise bout may have different effects on different forms of learning (e.g. motor skill learning vs motor adaptation) or in those with neurologic damage.
Learning of a motor task may be augmented when the neuro-motor system is prepared, or primed, prior to motor training. Successful priming interventions have included neuromodulation and a select number of motor based activities. Although error detection and correction are fundamental to motor learning, they have not been the targets of any previous priming interventions. Priming the error detection system via a cognitive task may enhance error detection, resulting in faster and/or more learning compared to unprimed conditions. Thus, the purpose of this study was to determine if priming error detection using a cognitive task immediately prior to motor training would augment learning of the trained motor task. Thirty healthy subjects (Mean ± SD age 25.6 ± 3.5 years) were randomized to either the experimental group (n=15) or the control group (n=15). The experimental group completed 400 trials of a computer based cognitive task (the Simon Task) with instructions to emphasis accuracy over speed, a manipulation that has previously been shown to heighten activity in brain centers involved in error detection and correction. The control group completed the same number of trials although their instructions were to emphasis speed over accuracy, a manipulation that has shown no increased activity in error detection and correction brain centers. All participants then completed 50 consecutive trials of a simulated feeding task. Trial time (in seconds) was the measure of motor performance, with faster times indicating better performance. Rate (i.e., improvement in response to training during acquisition) and amount (i.e., change in performance following a period of rest) of learning were calculated. There were no between-group differences in the rate of acquisition (p=.19). There was a main effect of time (p<.01), however, there was no main effect of group (p=.67) nor a group by time interaction (p=.50), suggesting that the error detection prime did not affect motor learning. Nevertheless, analyses of individual data (as opposed to group data), revealed that individuals who performed the cognitive task with an emphasis on accuracy (primed for error detection) learned the motor task at a faster rate (p<.01) than individuals who performed the cognitive task with an emphasis on speed (not primed for error detection). These results suggest that priming error detection prior to motor training may be a way to augment learning of a motor task. Further research is warranted to determine the validity of this priming technique as a means to augment motor learning/re-learning in individuals with impaired neuromuscular systems.
Introduction
Non-use, an acquired, transiently reversible behavioral response to suppress movement of the paretic limb, is a persistent problem in stroke survivors, but it is unclear whether level of sensorimotor impairment, cognitive, and/or psychological factors may influence its presence. We reasoned that paretic arm use may be modulated by level of sensorimotor impairment, confidence, side of stroke lesion, lateralized attention (neglect), arousal, and/or apraxia. In this pilot study, we sought to examine the influence of these factors on paretic arm use in chronic stroke survivors.

Methods
Twenty chronic stroke survivors (10 with left hemiparesis, 10 females) with mild-to-moderate motor impairment (Upper Extremity Fugl-Meyer, UEFM score > 30) participated. We administered the Actual Amount of Use Test (AAUT) (original spontaneous and modified forced use version), and used the relative difference between them as our primary non-use outcome: (forced – spontaneous)/forced. Predictor variables included: UEFM, the 10-item meaningless gesture imitation test --a measure of spatio-temporal apraxia, the Virtual Reality Lateralized Attention Test--a measure of both lateralized attention and non-lateralized attention or arousal, and the 20-item confidence in arm and hand movement questionnaire--a measure of task-specific self-efficacy. Response outcomes from the AAUT were a binary choice outcome (amount of use -- AOU) and another that represented the quality of movement (QOM) on a Likert scale. Both AOU and QOM were expressed as a percentage of the maximum total points, with separate scores for the spontaneous and forced conditions.

Results
The UEFM and self-reported confidence in arm and hand movements differentially predicted spontaneous and forced AAUT measures. Specifically, confidence correlated more strongly with spontaneous than forced use, both in terms of the choice to use the arm (sAOU, r = 0.59*), and quality of movement when movement was attempted (sQOM, r = 0.45*). Conversely, motor impairment correlated more strongly with forced (fAOU, r = 0.71**; fQOM = 0.57*) than spontaneous use. Arousal (non-lateralized attention) was a significant predictor of spontaneous choice (sAOU, r = 0.45*), as well as the primary relative non-use outcome (r = 0.45*), but not of sQOM (r = 0.07) or forced use measures (fAOU, r = 0.35; fQOM, r = 0.02). Neither apraxia nor lateralized attention significantly predicted any primary or secondary AAUT outcome.

Conclusions
Chronic stroke survivors who report greater confidence in task-specific movements of their arm and hand were more likely to ‘choose’ their paretic arm for spontaneous use. Conversely, motor impairment is closely related to the ‘ability’ to use the paretic arm, but not the choice to do so. Greater non-lateralized attention (i.e., general arousal) was linked to greater use of the paretic arm. Together, these findings suggest that psychological (i.e., confidence) and cognitive (i.e., arousal) factors may be determinants of non-use behavior.
Hebbian-Type Non-Invasive Stimulation of Motor Cortex Enhances the Effects of a Hand Motor Training in Chronic Stroke Patients

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After stroke of the primary motor cortex (ipsilesional M1) or its corticospinal projections (CST), plasticity in the peri-infarct tissue supports recovery of hand function. Hebbian-type repetitive transcranial magnetic stimulation (rTMS) of M1 is effective in enhancing the effects of a practice on motor learning and associated M1 plasticity in intact M1 (Buetefisch et al., 2004; 2015). Here we test the effects of Hebbian-type rTMS on hand motor training related behavioral gains and M1 plasticity in patients in the chronic phase after stroke involving M1 or its corticospinal projections. 20 patients were randomized to receive five days of motor training either paired with Hebbian-type rTMS (n=10, aged 59.7 ± 10.9 years) or sham rTMS (n=10, aged 62.6 ± 12.0 years) over ipsilesional M1. On each day of motor training, patients completed 360 auditory-paced wrist extension movements in a way that a cursor hit a target on a computer screen. The cursor encoded velocity and angle from a 2-dimensional accelerometer mounted on the dorsum of the hand. Increases in movement-related EMG activity of a muscle supporting the training movement were used to trigger TMS at the onset of the movement. Training-associated motor learning was defined by increases in peak wrist acceleration and M1 excitability. Movement kinematics (peak acceleration of wrist extension movement), motor function (Jebsen Test) and M1 excitability measures were determined before training, after a single training session (M1 function only), after a week of training and one month after training. M1 excitability was determined from a stimulus response curve (area under the curve (AUC)) collected for a training agonist (extensor carpi ulnaris (ECU)) and antagonist (flexor carpi ulnaris (FCU)) with TMS. After a week of training, only participants who received Hebbian-type rTMS experienced a significant increase after a week of training in movement kinematics (peak wrist acceleration, rTMS: +60.2%, sham: +39.7%) and in hand function (Jebsen, rTMS: -19.2%, sham: -8.6%) that persisted for 4 weeks (peak wrist acceleration, rTMS: +57.3%, sham: +35.3%; Jebsen, rTMS: -26.0%, sham: -10.3%). Patients who received Hebbian-type rTMS experienced a greater change in AUC for the ECU than FCU hotspot after a single training session those who received sham rTMS (ECU, rTMS: +0.31mV, sham: +0.33mV; FCU, rTMS: +0.04mV, sham: +0.67mV). The results suggest that Hebbian-type rTMS enhances training-related increases in hand function when applied to patients with chronic stroke. The results are consistent with previous reports of its effectiveness in intact M1. Hebbian-type rTMS may lead to greater motor improvement by facilitating training related motor learning in M1 neuronal networks supporting the training movement.
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To assay the physiology of the motor system, often the brain is stimulated and the muscle response, or motor evoked potential (MEP), is recorded. To understand the relationship between stimulation intensity and MEP, a recruitment curve is often produced. This S-shape curve details the complex input-output relationship between brain stimulation and MEP. Often, one would like to compare multiple recruitment curves that may correspond to different subjects, experimental conditions, and/or different points in time. Generating these curves from data and subsequently analyzing them can be arduous. For this purpose, we provide a software solution called Motometrics. The software uses an intuitive graphical user interface first to annotate and load acquired MEP data independent of the electrophysiological recording system. The user then chooses a signal metric such as the area under the curve to quantify MEPs. The data are fitted to an S-shaped recruitment curve, which in turn can be quantified using several metrics; users can choose a percentage of either the stimulus intensities or MEPs. The metric is applied to all recruitment curves to compare them. Motometrics is generalizable across humans and animals. It allows the experimenter to perform near real-time analysis of recruitment curves. As an open-source tool (https://bitbucket.org/burkemedicalresearch/motometrics), Motometrics is intended to grow with the needs of the motor physiology community.
T64: Resting Non-Dominant Arm Corticospinal Excitability is Dynamically Modulated by Dominant Arm Force rather than Intention and is higher in Old Compared to Young.

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Interhemispheric interactions between the two primary motor cortices are of principal importance in understanding functional lateralization, bimanual coordination, and recovery after hemiparesis. However, investigation of these motor network interactions using human motor evoked potentials has been limited in the range of network and behavioral dynamics examined. A more thorough understanding of movement-related motor interhemispheric dynamics could elucidate mechanisms of bimanual coordination, its age-related loss, and more specific targets for therapy.

Our objective was to determine how dominant-arm muscle contraction modulates non-dominant-arm corticospinal excitability and how older age impairs these dynamics. Network excitability and inhibition were tested across multiple stimulus-response recruitment intensities using single and paired pulse transcranial magnetic stimulation during a unimanual isometric muscle contraction. We hypothesized that resting non-dominant arm excitability would be modulated as a function of dominant arm force production and that older age would impair both inhibition and dynamics.

Our results demonstrate that dominant-arm isometric muscle contractions cause an increase in recruitment slope of resting non-dominant arm corticospinal excitability. This increase in non-dominant arm corticospinal excitability tracks with force production rather than motor intention. We also found that older participants exhibited increased excitability but not impaired interhemispheric inhibition or behavioral dynamics. Our findings demonstrate a mechanism that may underlie age-related impairments in bimanual coordination.
People with Parkinson’s disease (PD) are known to experience proprioceptive impairments along with motor deficits. Although anti-parkinsonian medications enhance proprioceptive function, medicated PD patients show significant proprioceptive deficits when compared with healthy adults. Sensorimotor training that challenges proprioceptive system are shown to improve proprioceptive acuity and translate to improved motor function in healthy adults. It is unknown whether proprioceptive function can be enhanced in PD by means of such behavioral intervention. We administered a visuo-proprioceptive training to PD patients using a wrist robotic device coupled with a real-time virtual visual environment to identify whether proprioceptive function in PD can be enhanced by specialized training that emphasizes precise movements and determine if such proprioceptive improvements lead to improved motor performance. 13 participants (Mean age = 61.8 yrs; mean disease duration = 2.5 yrs) diagnosed with primary Parkinsonism were tested in their ON medication state. Training involved tilting a virtual table to position a virtual ball on a target by making precise small amplitude wrist flexion/extension movements. All participants completed 60 training trials taking on average about 30 minutes for completion. With increasing proficiency, task difficulty was increased by adjusting the responsiveness of virtual ball. Wrist position sense acuity and spatial precision of an untrained goal-directed wrist movement were assessed without vision before and after training. Wrist position sense discrimination thresholds were obtained by controlled robotic passive motion providing paired stimulus wrist positions for the participants to discriminate. Mean movement precision error was determined using the absolute difference between passively presented target of 15° wrist flexion and subsequent active movement to the target by the participant. All participants showed improvements in wrist proprioceptive thresholds (mean: pre/post = 1.6° / 1.1°). On average, all patients showed 34% improvement in wrist proprioceptive thresholds after training. Wrist movement precision improved in 10/13 participants (mean: pre/post = 2.4° / 1.8°) by about 31% on average in those participants who showed improvements. Wrist proprioceptive function improves after brief specialized visuo-proprioceptive training in PD patients. Movement precision in an untrained motor task in most participants, indicating that such sensory-based training directly benefits motor function. These initial findings are promising and suggest that somatosensory-based training may enhance sensorimotor function in PD.
F1: Trade-off between Efficacy and Efficiency of Motor Training Post-Stroke

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It is well known from motor learning research that motor performance depends on the amount of practice, but also that the gains follow diminishing returns: each additional unit of training yields smaller and smaller gains. Recent results from the DOSE trial, a single blind, phase I, randomized controlled trial of four doses (0, 15, 30, or 60 hours) of upper extremity therapy during the chronic phase after stroke, showed a robust dose-response relationship for the Motor Activity Log-Quality of Movement (MAL-QOM) (Winstein et al., in preparation). Here, we test the hypotheses that: 1) increasing the dose of training leads to an increase in the efficacy of training, but a decrease in the efficiency of training, and 2) increasing the duration of training will also decrease the efficiency of training. We modeled the changes in the MAL during the train-wait-train-wait-train schedule used in the DOSE trial with novel dynamical mixed-effects models that account for individual response in changes in MAL both during and between training bouts. Using dose as input, we modeled the efficiency of training with dose; using time varying learning rates, we modeled the efficiency of training with duration; with the forgetting term, we modeled the decrease in MAL following training. Results confirmed the dose-response relationship previously found with regression models. The models also showed a decrease of efficiency with dose (the greater the doses, the less the gain per hour) and decrease in efficiency with time (the longer the duration of training, the less the gain per hour). In addition, the greater the dose, the more the forgetting following training. However, the random learning and forgetting coefficients showed a large between subject variability in both increase and decrease in MAL as a function of dose and time. In conclusion, our novel model well accounts for the individual effects of motor training post-stroke and exhibited a trade-off between the gains due to training on one hand and the intensity and duration of motor training on the other hand. In future work, models such as proposed here will help us to determine optimal schedules of training for individual patients post-stroke.
F2: Symmetry of Motor Planning for Initiating Stepping After Stroke.

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Introduction:
After stroke, many people exhibit difficulty with balance and walking, which could be the result of poor motor planning after stroke. This study examined motor planning for when the paretic leg was stepping, or standing to step with the non-paretic leg. Additionally, we examined whether cortical measures of motor planning related to motor performance or clinical measures.

Methods:
Ten individuals with subacute stroke (70.9±7.7 years; 6m, 4f, 3.9±1.5 months post-stroke) performed self-initiated stepping. The stepping leg alternated between sets. Electroencephalography (EEG) from the Cz electrode and electromyography (EMG) of biceps femoris (BF) and rectus femoris (RF) were collected; data were averaged 4 seconds before and after each step. Time from movement onset to peak knee flexion defined stepping speed. A co-contraction index between BF and RF muscles was calculated, as well as EMG onset latency and slope. The amplitude and duration of the movement related cortical potential (MRCP) was measured after averaging to the step onset. Paired t-tests compared stepping speed, EEG and EMG parameters between legs. Relationships among EEG, EMG, stepping speed and clinical measures were examined using Pearson’s correlations. One-way between groups ANOVAs compared the EEG and EMG measures for slow and fast steppers.

Results:
There were no differences between legs in stepping speed, EEG or EMG parameters (p≥0.069). The MRCP amplitude and duration associated with the paretic stepping were correlated with those of the non-paretic stepping (r=0.650-r=0.717). Within the paretic limb, MRCP amplitude correlated with duration (r=0.725), indicating longer planning time linked to higher cognitive effort. The paretic BF onset when the paretic leg was the standing or stepping leg was correlated with MRCP amplitude and duration (r=0.702-r=0.921). The non-paretic BF onset when the non-paretic leg was the stance leg correlated with MRCP duration (r=0.707). While there were no differences between slow and fast steppers on clinical or EMG measures, the slow steppers had larger MRCP amplitude when stepping with the paretic leg (F1,8=6.052, p=0.039) and longer MRCP duration (F1,8=6.295, p=0.036) when stepping with the non-paretic leg.

Discussion:
MRCP measures were correlated between legs demonstrating cortical motor planning for initiating stepping may be indicative of symmetry, as stepping speed was comparable between legs. The speed of stepping ability influenced cortical activity – individuals who stepped more slowly with the paretic leg had greater MRCP amplitudes and durations for planning a step. Further, cortical motor planning of a paretic or non-paretic step was associated with the onset of knee muscle flexor activity.

Conclusion:
This work is the first to investigate cortical motor planning for initiating stepping in individuals with stroke. It is possible that individuals who step slowly require more time and effort to plan a movement, which may mean the safety of these individuals in the community is compromised.
Rehabilitation is standard care after injury to the brain and spinal cord. As we look to incorporate therapies that promote nervous system repair into clinical practice, there is a gap in our understanding of how and when to combine restorative therapies into rehabilitation. Our laboratory has previously shown that electrical stimulation applied to the uninjured corticospinal tract after partial injury improves functional recovery and promotes axonal outgrowth in rats. The goal of our study is to determine the proper timing between electrical stimulation and rehabilitation. We hypothesize that electrical stimulation delivered two weeks before rehabilitation will be more effective than simultaneous application of the two therapies. Adult Sprague-Dawley female rats received a cut lesion of one corticospinal tract (pyramidotomy). Six weeks later, electrodes were implanted over motor cortex, and used to deliver 10 days of electrical stimulation, 6 hours a day, using our previously published protocol. Rats were randomized to receive rehabilitation during the stimulation period (30 minutes after stimulation) or 2 weeks later. To quantify forelimb skill, we used the knob task that measures supination, a critical component of forelimb dexterity that is impaired after corticospinal injury in both rats and humans. To quantify changes in corticospinal axon density, we anterogradely traced axons with biotinylated dextran amine and quantified axon length and distribution within the C6 segment of the spinal cord. Both groups of rats showed a strong and persistent impairment in forelimb supination at 6 weeks after injury. Early result show both groups make a large-scale and sustained recovery of supination with the onset around the time of rehabilitation. Anatomical analyses are ongoing and will be compared with behavioral recovery. Preliminarily, timing does not seem to be a critical variable for combining motor cortex stimulation and rehabilitation.
F5: Paired Motor Cortex and Cervical Spinal Cord Electrical Stimulation is Safe and Effective over Six Months in Awake Rats

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In our previous studies in anesthetized rats, motor cortex and cervical spinal cord paired electrical stimulation augmented motor function through converging descending motor and sensory afferent inputs into the spinal cord. Cervical spinal stimulation is challenging in awake animals due to narrow epidural space and large neck movement. We developed softening polymer-based electrode arrays (Fig. B), which are thin, flexible, and durable. These electrodes are stiff at room temperature and become supple after implantation into epidural space. We hypothesized that these spinal electrodes would be safe and effective for paired electrical stimulation in awake rats over months. Three sets of electrodes were implanted; spinal array electrodes over dorsal C5-C6, screw electrodes over motor cortex, and EMG electrodes in biceps muscle. We tested electrode impedance and spinal cord stimulation intensity required to provoke a motor evoked potential (MEP) over 6 months or until electrode failure. The effects of paired stimulation were tested in two ways. First, to test immediate effects of paired stimulation, we compared motor cortex evoked MEPs with and without subthreshold spinal stimulation delivered 10ms later. Second, to assess lasting effects of paired stimulation, we paired repetitively for 5 minutes and measured cortical MEPs and spinal excitability (spinal MEPs and H-reflex) before and after pairing. The spinal arrays take the shape of underlying spinal cord, as shown by MRI. Electrode impedance was stable up to 6 months, with small increases in spinal cord MEPs. Subthreshold spinal stimulation caused more than threefold increase in cortical MEPs compared to only motor cortex stimulation. Repetitive pairing caused strong augmentation of cortical responses and spinal excitability that lasted for more than an hour after 5 minutes of pairing. Both immediate and lasting effects of paired stimulation were observed to the 6 months. Thus, we conclude that paired stimulation is safe and effective for chronic stimulation and suitable for testing in motor recovery after CNS injury.

Key words: spinal cord; motor cortex; stimulation; electrical stimulation; flexible neural interface
Unilateral movements are predominantly controlled by the contralateral hemisphere, although ipsilateral motor cortex is known to be engaged depending upon task constraints. One dimension of task constraints is the dexterity of the motor task. In this study, we investigated the effects of manipulating task dexterity on ipsilateral (to the performing hand) motor cortex representation in patients with stroke. We used transcranial magnetic stimulation (TMS) to quantify motor corticospinal excitability, intracortical inhibition, and cortical facilitation of the ipsilesional and contralesional motor cortex projecting to the contralateral resting first dorsal interosseous (FDI) and Extensor carpi radialis (ECR) while participants with unilateral stroke performed unimanual tasks of differing complexity with their ipsilateral active hand. Less dexterous task required the participant to move light-weight plastic balls to specific targets placed 8 inches away using a whole-hand grasp. More dexterous task required participants to move Purdue pegs to targets placed 8 inches away using a precision grip. TMS was timed to the beginning of the transport phase of the movement. While the paretic arm was slower than the nonparetic arm, patients performed the less dexterous task with faster speeds compared to the more dexterous task with both arms. For motor cortical excitability, quantified using MEP amplitude evoked by suprathreshold TMS pulse, there was a significant muscle X task X hemisphere interaction. While performing the tasks of different dexterity with the nonparetic arm, there was no differential modulation of the resting ipsilesional motor cortex projecting to ECR or FDI. In contrast, less and more dexterous task performance with the paretic hand had differential effects on the excitability of the contralesional motor cortex projecting to FDI, but not ECR. Compared to the less dexterous task, performance of the more dexterous task with the paretic arm was associated with a significantly greater increase in the excitability of the contralesional motor cortex projecting to FDI. However, dexterity-dependent changes in contralesional motor cortex during paretic arm performance were not reliable for ECR. Increase in FDI motor cortical excitability of the contralesional hemisphere during more dexterous task were associated with reduced short-interval cortical inhibition and an increase in intracortical facilitation. Our findings indicate that dexterity requirements of the motor task modulate the role of the contralesional motor cortex in paretic arm performance after unilateral stroke, and these effects are specific to muscles that are responsible for greater levels of dexterity.
After stroke affecting hand function, abnormally high activity in primary motor cortex (M1) ipsilateral to the affected hand is often observed during performance of motor tasks. However, the importance of this increased activity in supporting motor function after stroke remains unclear. One possibility is that higher ipsilateral M1 activity reflects cortical reorganization that contributes to motor recovery. Alternatively, greater M1 activity may simply reflect that the execution of hand movements becomes more demanding due to impairment of hand function. To understand the contributions of these alternative mechanisms, we assessed movement kinematics and blood oxygenation level-dependent (BOLD) activity patterns, as measured by functional magnetic resonance imaging (fMRI), during unimanual performance of a task that varied in the demand on accuracy. The demand hypothesis predicts that M1 activity would vary as a function of demand in both stroke patients and healthy control participants. In contrast, finding a differing relationship between M1 activity and demand in patients and controls would suggest that activity changes are in part a function of reorganization processes.

Patients (1 month after stroke) and healthy controls used an MRI-compatible joystick to move a small cursor into a target in one of four possible locations. Motor demand was manipulated by varying target size (small, medium, large, extra-large) across blocks of four movement trials. EMG activity of the extensor carpi ulnaris muscle was used to verify absence of movement of the non-moving hand. Across movement performance measures, patients performed worse with the affected hand compared to control participants. However, both patients and controls showed similar changes in performance across target sizes, such that movement execution parameters (i.e., accuracy, movement time), but not preparation-related parameters (i.e., reaction time, initial angular error) scaled with task demand. Univariate analysis of the BOLD signal showed demand-dependent increases in M1 both contralateral and ipsilateral to the moving hand. At each target size, patients exhibited greater M1 activity relative to controls that was related to, but not entirely explained by, longer movement times. Furthermore, representational similarity analysis of the multivoxel patterns within M1 showed evidence for distinct activity patterns for movements of different target sizes in control participants. At the group level, patients showed no clear relationship between target size and M1 activity patterns, though this may be due to individual differences in stroke location and handedness. Together, the results suggest that greater M1 activity following stroke can be characterized as an interplay between distinct neural representations for different levels of movement difficulty in addition to M1 reorganization unrelated to task demand.
Objective
The aim of this study is to use a human intracortical Brain Computer Interface (BCI) to investigate the neural dynamics of motor learning and motor system plasticity at the scale of single neurons and local field potentials.

Background
Recent studies employing brain computer interfaces in non-human primates have revealed fundamental insights into the neurophysiology of motor learning. The tuning properties of individual neurons evolve, and groups of neurons consolidate into stable networks. Studying the correlates of BCI learning in humans has traditionally been a more challenging task because to enable optimal BCI control of effectors, neural decoding algorithms need to adapt to non-stationary signals. Thus, real-world BCI decoders exhibit changing input features as well as model parameters making inferences about motor learning difficult to interpret.

Design/Methods
Here we present a Local Field Potential (LFP)-based decoding paradigm that allows human participants enrolled in the BrainGate2 clinical trial to learn a relatively simple and arbitrary map between LFP power in the low-gamma range and one-dimensional cursor control. Specifically, the smoothed LFP power in the low-gamma range (40 – 55 Hz) from a single electrode selected from two 96-channel microelectrode arrays (Blackrock Microsystems, Salt Lake City, UT) placed in the dominant motor cortex was mapped based on threshold percentile values to constant speed leftward, resting, or rightward directional control of a cursor (paddle) during the game “Pong” presented on a computer screen.

Results
The decoder was successfully tested online with BrainGate2 clinical trial participant (T9), a 54 year-old man with amyotrophic lateral sclerosis. Our preliminary results indicate that T9 was able to improve directional control ability over the course of a single 30-minute session using this fixed decoder. We plan to analyze performance in additional participants over multiple days to assess for participant learning and subsequently analyze the evolving relationships between local field potentials and neuronal action potentials both on the control electrode and across both microelectrode arrays.

Conclusions
This study illustrates the ability to use an intracortical brain-computer interface with a fixed, LFP-based, simple decoder to analyze the spatial and temporal neural dynamics of human motor learning. The results of this study will have implications for understanding human motor system plasticity and for the design of BCIs for neurorehabilitation.
Background/Objectives.
Infants with brain insults are at high risk for cerebral palsy (HRCP) and have reduced selective hip-knee control. We developed an in-home intervention to encourage selective hip-knee control. It uses a Microsoft Kinect to track an infant’s leg movements and activate an overhead infant mobile based on specific kicking actions. The purpose of this study is to determine: (1) the feasibility of the in-home intervention, (2) if infants at HRCP and infants with typical development (TD) learn the contingency between leg movement and mobile activation, (3) if both groups increase selective hip-knee control when activating the mobile compared to spontaneous kicking.

Study Participants.
6 infants at HRCP and 12 infants with TD at 3½-months corrected-age.

Methods.
Each infant participated in an 8-10 min/day, 5 day/week, 6-week in-home intervention. On the first day of each week, the spontaneous kicks of each infant were assessed for 2-min, followed by 8-min of the infant playing with a mobile that activated based on specific kicking actions. For the next 4 days, the infant played with the mobile for 8-min/day. At the end of 6-weeks, parents answered questions about feasibility. Learning was assessed weekly based on an increase in the proportion of time that the infant demonstrated the reinforced leg actions (RLA) when playing with the mobile compared to spontaneous kicking. Selective hip-knee control was assessed weekly based on a decrease in the hip-knee correlation coefficient (CC) of kicks that activated the mobile compared to spontaneous kicking. For the group with TD, mixed models using repeated measures were used to analyze RLA and hip-knee CC. Infants at HRCP were not analyzed statistically due to small sample size.

Results.
Feasibility: Parents stated the in-home intervention was easy to implement. Adherence was 93-100%. Learning: All infants learned that their leg action activated the mobile: infants with TD met the individual learning criteria for a median of 5 weeks (range 3-6), and infants at HRCP met the criteria for a median of 3 weeks (range 2-4). For 5 of 6 weeks, the group with TD demonstrated an increase in RLA when activating the mobile (21.9±1.1%) compared to spontaneous kicking (10.2±1.7%, \( p<0.0001 \)). Selective hip-knee control: For these 5 weeks, the group with TD demonstrated a decrease in hip-knee CC when activating the mobile (0.32±0.08) compared to spontaneous kicking (0.59±0.08, \( p<0.0001 \)). For the weeks they learned, 4 infants at HRCP demonstrated a decrease in hip-knee CC when activating the mobile compared to spontaneous kicking.

Conclusions/Significance.
The mobile intervention is feasible. Preliminary data supports that some infants at HRCP can learn that their leg actions activate the mobile, and demonstrate more selective hip-knee control when activating the mobile compared to spontaneous kicking. Further research is necessary to determine if participation in interventions to reinforce selective hip-knee control increases selective hip-knee control of infants at HRCP and results in improved functional outcomes.
Introduction:
Neural networks involved with memories are strengthened throughout the course of sleep via spontaneous ‘replaying’ in activity-related local brain regions. Non-invasive methods of sensory stimulation during sleep have been developed to selectively enhance this process. The most widely used method is known as targeted memory reactivation (TMR), which involves classical conditioning of an auditory cue paired with task performance at the time of initial motor skill acquisition, followed by replaying the same cue during sleep. Application of TMR during sleep, but not wake, activates the brain regions involved with initial skill acquisition leading to increased functional connectivity within related brain networks. We have previously demonstrated that TMR throughout the first two slow wave cycles of sleep feasible to enhance non-dominant arm throwing accuracy. However, it is unknown whether TMR application throughout a one-hour daytime nap is sufficient to produce measurable effects in performance.

Methods:
Thirty three right-handed individuals were randomized into one of four groups (differentiated by between-session activity): wake without TMR, wake with TMR, sleep with TMR, or sleep without TMR. The training protocol involved two 30-minute sessions of repetitive throwing of a small ball using the left upper extremity to five unique visuospatial targets with distinct auditory cues paired with each target. Mean absolute throwing error was collected immediately before and after the one-hour between-session interval.

Results:
Preliminary results show between-group differences in absolute error change score ratios between-sessions (Wake without TMR: 0.2708; Wake with TMR: 0.1239; Sleep without TMR: 0.0524; Sleep with TMR: -0.8317; $p=0.012$), where negative ratios indicate improved accuracy.

Conclusions:
These initial results suggest that auditory cues enhanced spatial accuracy across the one-hour sleep interval. Further data collection and analyses are planned. Results of this research are expected to serve as a step towards a follow up study to enhance upper extremity training protocols in individuals post-stroke.
Upper limb (UL) hemiparesis is frequently a disabling consequence of stroke. The ability to improve UL functioning is associated with motor relearning and experience dependent neuroplasticity. Interventions such as non-invasive brain stimulation (NIBS) and task-practice in virtual environments (VEs) can influence motor relearning as well as modulate adaptive plasticity. However, the effectiveness of a combination of NIBS and task-practice in VEs on UL motor improvement has not been systematically examined in people who have sustained a stroke. We examined the evidence regarding the effectiveness of combining NIBS with task-practice in VEs on UL motor impairment and activity levels in people with stroke. We conducted a systematic review of the published literature in English language using standard methodology. Sackett’s ratings adapted to include PEDro scores were used to assess study quality for Randomized Controlled Trials (RCTs). Non-RCTs were evaluated using Down's and Black checklist scores. Four studies (three RCTs and one cross-sectional study) examining the effects of a combination of NIBS were retrieved. The retrieved studies involved use of both transcranial direct current stimulation; tDCS as well as repetitive transcranial magnetic stimulation; rTMS. There is 1a level evidence that the combination of NIBS and task-practice in a VE is beneficial in the sub-acute stage. A combination of training in a VE with rTMS (one RCT, 1b level) as well as tDCS (one RCT, one cross-sectional study, level 1b) was beneficial for motor improvements in the UL in sub-acute stage of stroke. The combination was not found to be superior compared to task practice in VEs alone in the chronic stage (level 1b; one RCT). The results suggest that levels of motor impairment and activity in the sub-acute stage can be improved if the rehabilitation program involves a combination on NIBS and VE training. Emergent questions regarding the use of more sensitive outcomes, different types of stimulation parameters, stimulation location and training environments still need to be addressed. Answers to these questions will assist in the selection of most appropriate training environments and stimulation parameters to maximize upper limb motor improvement.
Stroke is a leading cause of long-term disability globally. Prior work examining subcortical volumes in relation to motor behavior in stroke patients found that the side of the lesion influenced the brain-behavior relationship. In this study we used a vertex-wise shape analysis to further investigate the relationship between subcortical morphology, laterality, and motor status in chronic stroke survivors. We also compared results between subcortical morphometry and volume.

Participants included patients with right hemisphere lesions (RHL; n=83; age=57.1±12.4yrs) and left hemisphere lesions (LHL; n=120; age=58.1±12.8yrs) from 6 enrollment sites within the ENIGMA Stroke Recovery working group. FreeSurfer v5.3 was used to segment volumes for 14 regions of interest from T1-weighted structural MRI (ROI; bilateral thalamus, caudate, putamen, pallidum, hippocampus, amygdala, and accumbens). Radial distance (RD) and Jacobian determinant (JD) were calculated vertex-wise as morphometric measures of shape. RD was calculated using the distance between the surface and the medial curve and JD as a representation of the surface dilation ratio between the shape and a surface template. We used a linear regression to test for the effect of motor score on JD and RD in each ROI. Motor score was calculated as a percentage of the maximum possible score for each scale to represent degree of motor behavior (Fugl-Myer, Wolf Motor Function Task). We assessed linear models including all stroke participants, as well as RHL and LHL, separately. Age, sex, enrollment site, and intracranial volume were accounted for as fixed effects. Lesioned hemisphere was also accounted for in the combined model. The significance threshold was corrected for multiple comparisons (False Discovery Rate (FDR) method; p=0.05). We also analyzed overall subcortical volumes using the same linear models.

The combined model found significant positive associations (p<0.05, FDR) between RD and motor scores for regions in the right posterior thalamus and anterior caudate, and positive associations between JD and motor scores in the right anterior caudate, posterior thalamus, and putamen, meaning larger RD and JD correlated with higher motor scores. In contrast, the subcortical volume analysis only detected a similar positive effect in the right caudate (p=0.0001). When analyzing the RHL subgroup, the strongest positive association was JD in the right anterior caudate, with 70% of vertices affected. Significant positive relationships were also found for RD and JD in the right posterior thalamus. The volumetric analysis detected a similar relationship in the right caudate (p=0.0009). The LHL group shape analysis showed no significant trends for either shape or volumetric analysis.

We conclude that within our data, higher motor score correlates with increases in JD and RD of the aforementioned regions. The results suggest that shape analysis may be a useful tool for detecting subtler morphological differences in post-stroke neuroanatomy, which volumetric analyses might not be able to identify.
Age-related neuronal changes that impact motor function can lead to a decrease in effective motor control. Repetitive transcranial magnetic stimulation (rTMS) has the potential to modulate neuronal plasticity in healthy aging adults, which may yield changes in motor control. However, little research exists on the influence of age with motor practice or motor practice plus rTMS. The purpose of this study was to examine how rTMS alone, motor practice alone, and rTMS paired with motor practice influenced neuroplasticity and motor skills in healthy adults. Methods: Thirteen subjects participated in the three different intervention protocols, one per visit separated by a minimum of 48 hours. The interventions included 30 bouts of 6 seconds of wrist extension during the motor practice only, 30 trains of subthreshold 10 Hz stimulation during the rTMS only, and a combination of the two during the motor practice and rTMS intervention. To measure the effect of the interventions, the Box and Blocks Test (BBT), wrist extension force steadiness at 20%, and TMS outcomes (cortical excitability and short-interval intracortical inhibition) were assessed immediately before and after the intervention. Change scores for the TMS measures were calculated to measure neurophysiological changes from baseline and data were analyzed using an ANOVA. Results: The BBT data demonstrated a significant main effect for time for the right upper extremity ($p=0.02$), but not for the left upper extremity ($p>0.05$). During the force steadiness testing at 20% of max force, there was a main effect for time ($p=0.025$) but no difference between conditions. A significant interaction was observed in both TMS outcomes across muscles, conditions, and subjects. The combined intervention (motor practice plus rTMS) differentially targeted the extensors versus the flexors. Conclusions: This study highlights trends that rTMS coupled with motor practice has the potential to target active muscle groups (extensors in this study), while inhibiting inactive antagonist muscle groups (flexors). This finding adds to the understanding that pairing non-invasive brain stimulation with motor practice can have differential effects. This is an area of interest that should continue to be explored given the potential clinical implications of this approach.
F15: Proprioception Impairments in Children with Unilateral Spastic Cerebral Palsy Measured with a Markerless Motion Capture System

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Background/Objective:
Proprioception – the ability to sense the position of a limb in space without visual feedback – is an important contributor to motor control. Although it is known that neurological impairment often causes proprioception deficits, there are few reliable, quantitative scales that accurately, affordably measure proprioception. We developed and tested a proprioception assessment platform that easily, non-invasively quantifies proprioception.

Participants:
31 children with unilateral spastic cerebral palsy (6.1-17.3y, 12 females) and 21 typically-developing children (6.3-17.9y, 12 females).

Methods:
Our proprioception assessment used a Microsoft Kinect 2. The child was seated, blindfolded, 1m from the Kinect. Children performed three different tasks. In each task, the experimenter first moved the child’s arm (model arm) to a raised position lateral to the trunk. The child would hold the model arm in position for three seconds. During this interval, the Kinect would capture xyz coordinates of each of the child’s upper body joints. In task 1 (ipsilateral remembered), after the child held the model arm in position, the child would relax the arm to the side of the body, then reposition the same arm (test arm), in the same position as the model arm had been placed. In task 2 (contralateral remembered), after the child held the model arm in position, the child would relax the arm to the side of the body, then position the contralateral arm (test arm) in a position that mirrored the model arm position. In task 3 (match), after the child held the model arm in position, the child would maintain the position of the model arm, and position the contralateral arm (test arm) to mirror the position of the model arm. During each task, the Kinect would capture coordinates of the test arm after the child had positioned the arm. Both the more- and less-impaired arms were used as the model and test arm for each task. Differences in joint positions of the model vs. test arm were quantified in MATLAB. We measured unimanual hand movement speed using the Jebsen-Taylor Test of Hand Function (JTTHF), bimanual hand use with the Assisting Hand Assessment (AHA), and functional hand use with the Canadian Occupational Performance Measure (COPM).

Results:
Children with USCP showed substantial deficits in proprioception compared to typically-developing children. The match task was the most sensitive for detecting proprioception impairments. Children with more severe proprioception deficits were most impaired in functional hand use (COPM) and unimanual hand use (JTTHF).

Conclusions/Significance:
Proprioception is an important component of motor control, but has been difficult in the past to quantify. Our system can quantify proprioception in children with USCP using low-cost technology. This tool can be used to further understand proprioception in children with CP.
F16: Muscle Coordination of Isometric Force Development in Stroke

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Previous studies suggest that activation of a small number of motor modules (i.e., coordinated patterns of muscle activity that flexibly combine to produce functional motor behaviors) underlies isometric force generation in stroke survivors and neurologically intact individuals. Our previous study demonstrated that stroke induces alterations in the composition of motor modules in the way that activation of some muscles is abnormally coupled. As we identified the ‘post-stroke’ alteration of modular organization of multi-directional force production during the stable force match phase, it remains unclear whether similar changes also occur during the ‘dynamic’ phase of converging to solution (i.e., during force development). We thus examined whether stroke-specific motor module patterns also emerge over the exploratory course of isometric force matches. EMG was recorded from eight major muscles of the affected arm of eight chronic stroke survivors with severe impairment (Fugl-Meyer UE score < 25) and both arms of six age-matched control participants, during a 3-dimensional isometric force matching task. A non-negative matrix factorization algorithm identified motor modules in two time windows: exploratory force ramping phase, and stable force match. Correlation coefficients between any potential pair of end-point force components were also computed for the same time windows. Motor modules are conserved throughout the entire duration of isometric force development in both subject groups, as the same set of motor modules was identified during both phases of force generation. In stroke, the atypical co-activation of the three heads of the deltoid was conserved throughout force development. In both groups, all computed force correlations were significantly higher (p < 0.05) during the force ramping phase compared to stable force generation. In stroke, a higher force directional error was observed during the force ramp phase (p < 0.05). For both stroke and control groups, the CNS modulated the activation of the same set of motor modules to ramp up and stably maintain force, and the ‘abnormality’ in the composition of motor modules (and their improper tuning) appears to have contributed to the performance degradation post-stroke.
F17: Effects of Aging on GABAα Receptor Function after Midazolam Administration

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The current study investigates the effects of the administration of benzodiazepine receptor agents on measures of inhibition as assessed by transcranial magnetic stimulation (TMS). In this ongoing work, 20 older (50-70) and 20 younger (18-38) participants for multiple sessions involving TMS during which an anesthesiologist administers an intravenous (IV) dose of midazolam (a benzodiazepine GABAα agonist) or flumazenil (a GABAα receptor antagonist). Prior to medication administration, baseline TMS assessments of cortical inhibition are acquired using the protocols: short interval intracortical inhibition (SICI), long interval intracortical inhibition (LICI), short interval interhemispheric inhibition (SIHI), long interval interhemispheric inhibition (LIHI), and cortical silent period (SP) assessment. SIHI and LIHI protocols involved both a passive (resting) stimulation and active (25% pinch squeeze of first dorsal interosseous). Between SIHI and LIHI acquisition participant we assessed wakefulness via pupillary constriction velocity using a handheld pupillometer. After the baseline TMS protocol is acquired, the anesthesiologist administers a bolus of either midazolam or flumazenil. After 5 minutes, the participant receives a continuous IV drip of the medication to reach stable anesthesia effect. After this point, TMS is again acquired using the same parameters as above. After acquisition, the participant receives a bolus of midazolam or flumazenil as a reversal agent and then a mixture drip with saline for 5 minutes. Again, pupillary constriction is assessed with the target velocity set at approximately 90-110% of baseline rate. In a separate session, participants also completed a battery of cognitive and motor assessments.

Preliminary analysis of 14 younger adults and 12 older adults shows that older adults have higher and more variable resting motor thresholds as compared to younger adults. Older adults have shorter cortical silent periods at baseline and more variable intracortical inhibition measures (LICI, SICI). After administration of midazolam, LICI is considerably decreased in older adults while this measures is unchanged in younger adults. Interestingly, while SIHI and LIHI show no age group differences at rest, both at baseline and after midazolam administration, significant age group differences in interhemispheric inhibition were revealed in comparison of SIHI and LIHI during the active condition. These data indicate that an interaction of inhibitory cortical networks mediated by multiple GABA receptor subtypes is involved in aging-related changes in cortical inhibition.
F18: Tailoring Non-Invasive Brain Stimulation to Enhance Bimanual Arm Coordination in Individuals with Chronic Stroke

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Using non-invasive brain stimulation (NIBS) as an adjunctive therapy has become increasingly popular in stroke rehabilitation. Current protocols have focused on the interhemispheric competition model which emphasizes facilitation of the lesioned hemisphere or inhibition of the non-lesioned hemisphere. Few studies have examined the effects of NIBS on bimanual arm function. The purpose of this study was to examine the neuro-modulation effects of iM1 vs. cPMd on interlimb coordination and cortical function in individuals with chronic stroke. We hypothesized that subjects would show differential responses to these two types of stimulation and that these differences may be associated with their levels of paretic arm function.

Subjects:
Eight subjects with chronic stroke.

Methods:
Using a repeated measures design, subjects received a single session of 5Hz repetitive transcranial magnetic stimulation (rTMS) on either iM1 or cPMd. During each session, subjects performed isometric elbow flexion tasks with a single arm or both arms while matching a visual target corresponding to 20% of their maximal voluntary contraction. Outcomes included motor evoked potential amplitude (MEPs) of M1 bilaterally, force performance, and muscle coherence of the two arms during the bimanual task.

Results:
Six subjects showed greater MEP amplitudes in the lesioned M1, and decrease of MEPs in the non-lesioned M1 after iM1 stimulation (p<.05). Muscle coherence between two arms during the bimanual task also increased after iM1 stimulation (p<.05). In contrast, two subjects demonstrated greater MEP amplitudes in the lesioned M1 after cPMd compared to iM1 stimulation. Muscle coherence between the arms during bimanual tasks also increased after cPMd, but not iM1 stimulation. A regression model showed the percentage change of MEP amplitude of lesioned M1 was significantly correlated with distal arm function of Fugl-Meyer assessment scores (p=.03, R²=.63).

Conclusion:
Our study identified two different patterns of response after rTMS to iM1 and cPMd in subjects with chronic stroke. Subjects with more impaired distal arm function, may benefit more from direct enhancement of cPMd than lesioned M1. Our preliminary findings indicate that protocols of NIBS should be individualized to each subject.
F19: Combined Cortical and Peripheral Nerve Stimulation Effects in Patients with Stroke and Moderate to Severe Upper Limb Motor Impairment

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Introduction
Transcranial direct current stimulation (tDCS) and somatosensory stimulation in the form of peripheral sensory stimulation (PSS) have emerged as potential powerful tools to enhance motor performance or increase effects of motor training in stroke victims.

Objectives
To compare effects of active PSS+tDCS, tDCS alone, PSS alone and sham PSS+tDCS as add-on interventions to motor training in patients with stroke and moderate to severe upper limb impairments.

Methods
Patients > 6 months post-stroke underwent four different interventions, in a cross-over design: repetitive training of wrist extension of the paretic arm preceded by either active PSS (median, ulnar and radial nerves), active anodal tDCS of the affected hemisphere, sham PSS+tDCS or active PSS+tDCS. Before and after each session, the following outcomes were blindly evaluated in the paretic upper limb: range of movement (ROM) of wrist extension (primary outcome); ROM of wrist flexion, grasp and pinch strength. Measures were compared with analysis of variance with repeated measures (ANOVARM) with factors “session” and “time”.

Results
After screening 2499 patients, 22 subjects were included in the study (14 men). The mean age (± standard deviation) was 55.2±12.9 years and the mean time from stroke, 5.3±5.6 years. The mean Fugl-Meyer score for the paretic upper limb was 37±7.9. Two patients were excluded (one dropped out and one received botulinum toxin treatment). There was a significant effect of “time” (F=4.6, p=0.046), but no effects of “session” or interaction “session x time” in regard to grasp force. There were no significant effects of “session”, “time” or interaction “session x time” in regard to ROM of wrist extension, wrist flexion, or pinch force.

Conclusions
Repetitive training of wrist extension specifically improved grasp force and did not influence other outcomes. PSS+tDCS, tDCS alone or PSS alone did not potentiate the effect of training.
F20: Dexterity: Software for Analysis and Visualization of Automated and Manual Motor Tasks

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Hand function is critical for independence, and neurological injury often impairs dexterity. To measure hand function in people or forelimb function in animals, sensors are employed to quantify manipulation. These sensors make assessment easier and more quantitative and allow automation of these tasks. While automated tasks improve objectivity and throughput, they also produce large amounts of data that can be burdensome to analyze. We created MATLAB software called Dexterity that simplifies data analysis of both automated and non-automated forelimb tasks. Through a graphical user interface, files are loaded and data are identified and analyzed. These data can be annotated or graphed directly. Analysis is saved, and the graph and corresponding data can be exported. For additional analysis, Dexterity provides access to custom MATLAB scripts created by other users. To determine the utility of Dexterity, we performed a study to evaluate the effects of task difficulty on the degree of impairment after corticospinal injury; the task analyzed was an automated forelimb supination task for rodents (Vulintus, Inc.). Dexterity analyzed two months of data quickly and allowed new users to annotate the experiment, visualize results, and save and export data. We also analyzed data from a non-automated task, the Vermicelli Manipulation task, and another automated task, the isometric pull task (Vulintus, Inc.) before and after motor cortex lesion. Dexterity made the tools required to analyze, visualize and annotate data easy to use by investigators without data science experience. In future, we plan to assess analogues forelimb data from human robots as well that will make the human and animal model data more comparable.
Background and objective:
A prior meta-analysis revealed that higher doses of transcranial direct current stimulation (tDCS) have a better post-stroke upper-extremity motor recovery. While this finding suggests that currents greater than the typically used 2 mA may be more efficacious, the safety and tolerability of higher currents have not been assessed in stroke patients. We aim to assess the safety and tolerability of single session of up to 4 mA in stroke patients.

Methods:
We adapted a traditional 3 þ 3 study design with a current escalation schedule of 1»2»2.5»3»3.5»4 mA for this tDCS safety study. We administered one 30-min session of bihemispheric montage tDCS and simultaneous customary occupational therapy to patients with first-ever ischemic stroke. We assessed safety with pre-defined stopping rules and investigated tolerability through a questionnaire. Additionally, we monitored body resistance and skin temperature in real-time at the electrode contact site.

Results:
Eighteen patients completed the study. The current was escalated to 4 mA without meeting the pre-defined stopping rules or causing any major safety concern. 50% of patients experienced transient skin redness without injury. No rise in temperature (range 26Ce35 C) was noted and skin barrier function remained intact (i.e. body resistance >1 kU).

Conclusion:
Our phase I safety study supports that single session of bihemispheric tDCS with current up to 4 mA is safe and tolerable in stroke patients. A phase II study to further test the safety and preliminary efficacy with multi-session tDCS at 4 mA (as compared with lower current and sham stimulation) is a logical next step. ClinicalTrials.gov Identifier: NCT02763826.
In stroke, the influence exerted by the contralesional motor cortices upon recovery of the paretic upper limb remains widely debated. It was originally believed that contralesional motor cortices have a negative influence, based on the findings that contralesional cortices exerted excessive amounts of inter-hemispheric inhibition (IHI), and demonstrated greater relative activation than ipsilesional regions during paretic hand movement following stroke. But recent evidence has claimed contralesional motor cortices have a positive influence, according to the findings that contralesional motor cortices take a supportive role in movement of the paretic upper limb. This debate may find resolution in a recent hypothesis, known as the bimodal-balance recovery hypothesis. The hypothesis explains that the influence exerted by the contralesional motor cortices is “bimodal”, negative in minimally affected patients, but positive in patients who experience severe ipsilesional damage. Although this hypothesis is valuable for designing individualized treatments, the critical level of damage and impairment that stratifies patients based on the differing roles of the contralesional motor cortices remains unknown. The goal of the present study was to identify such a critical threshold. Twenty-four patients (age: mean±se: 62±2 years) with first-ever stroke underwent transcranial magnetic stimulation (TMS) and functional MRI (fMRI) for measurement of the influences exerted by the contralesional motor cortices, indexed as IHI and relative activation of contralesional vs. ipsilesional motor cortices (laterality), respectively. Severity of impairment was assessed using the Upper Extremity Fugl Meyer (UEFM) scale. Severity of damage was quantified as loss of structural integrity of ipsilesional vs. contralesional pathways (Fractional Anisotropy asymmetry index, FAAsymmetry) studied using Diffusion Tensor Imaging, and as physiologic excitability of residual ipsilesional pathways (active motor threshold, AMT), studied using TMS. We determined how the influence exerted by the contralesional motor cortices (IHI and fMRI laterality) varied with impairment and damage (UEFM, FAAsymmetry and AMT). Based on the type of the relationship (linear or non-linear), linear or quadratic regression model was adopted to stratify patients into two sub-groups. We found that the relationship between IHI and impairment or damage was parabolic, with the critical thresholds located at UEFM = 39 and FAasymmetry = 0.221. In patients who were more affected than these thresholds, IHI was weaker with more impairment/damage, but in patients who were less affected than the threshold, IHI was stronger with more impairment/damage. The relationships between severity of damage and fMRI laterality of primary motor cortex and cerebellum was linear, with critical thresholds identified at AMT = 42 & 49, respectively. Patients who were more affected showed higher relative activation of contralesional vs. ipsilesional regions. These results validate the bimodal hypothesis about differing influences exerted by the contralesional motor cortices and provide critical thresholds of impairment and damage for designing precise rehabilitation protocols, based on their mechanisms of recovery.
F23: SHIPS: Studying Successful Upper-Extremity Motor Recovery Post Stroke

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Upper-extremity (UE) impairment affects 88% of stroke survivors due to dysfunctional shoulder-hand coordination. Patients may be able to grasp with the arm at rest but unable to grasp in a functional context (e.g. from a high shelf) because shoulder use elicits involuntary hand muscle activity. Further, much rehabilitation research is directed at unsuccessful stroke recovery but little towards patients with successful clinical recovery even though they attain the desired rehab outcome. We examined the neurophysiological trajectory of successful compared to unsuccessful post-stroke recovery in the context of functional UE movements. Using transcranial magnetic stimulation in patients, we tested whether shoulder position influences corticomotor excitability and intracortical inhibition of hand muscles involved in grasp (first dorsal interosseous, flexor pollicis brevis, extensor digitorum, and flexor carpi radialis). We tested three groups: 1) mildly-impaired patients, representing those who will show successful post-stroke recovery Early, at <17, 30-, 90-, and 180-days after stroke, 2) moderately-impaired patients representing those with persistent impairment and incomplete post-stroke recovery in the Chronic stage (> 6-months post stroke), and 3) age-matched healthy Controls. UE motor function recovery was measured using the UE Fugl-Meyer, Jebsen-Taylor hand function test, and Stroke Impact Scale. Data collection is underway. Preliminary results in age-matched controls show that shoulder position differentially influences corticomotor excitability of hand muscles involved in grasp. We hypothesize that this centrally-facilitated, shoulder-hand coupling is dysfunctional after stroke resulting in involuntary coactivation of UE muscles and persistent impairment. These findings will help distinguish the neurophysiology of successful from unsuccessful UE motor recovery following stroke, leading to more effective, mechanism-based interventions for UE dysfunction.
For patients with stroke, it is generally believed that deficits of the upper limb persist due to disproportionate amounts of inhibition imposed from the contralesional upon the ipsilesional hemisphere. A common rehabilitation strategy, therefore, involves engaging the paretic upper limb in intensive unilateral activities so the ipsilesional hemisphere can counter such inhibition. What remains unclear, however, is why bilateral rehabilitation strategies, that theoretically engage the contralesional and the ipsilesional hemisphere, yield benefit for paretic upper limb movement. We address this question by comparing neurophysiologic mechanisms underlying one session of unilateral cyclic neuromuscular electrical stimulation (cNMES) and one session of bilateral contralaterally controlled functional electrical stimulation (CCFES). In a repeated-measures crossover experiment, sixteen patients with chronic stroke with varying degrees of motor impairment (Upper Extremity Fugl-Meyer score = 7 [severe] to 63 [mild]) underwent single sessions of unilateral and bilateral therapy. The therapy involved assisted repetitive neuromuscular electrical stimulation for 45 minutes to the paretic upper limb alone controlled by an external device (unilateral cNMES) and assisted neuromuscular electrical stimulation to the paretic upper limb controlled by symmetrical movement of the non-paretic upper limb (bilateral CCFES). We measured the inhibition exerted by the contralesional hemisphere upon the ipsilesional hemisphere, the corticospinal output originating from the ipsilesional hemisphere to supply the paretic upper limb and the uncrossed, ipsilateral output originating from the contralesional hemisphere to supply the paretic upper limb using transcranial magnetic stimulation. Overall, bilateral CCFES led to greater reduction in inhibition upon the lesioned hemisphere (-13±20% vs. -2±22%, F(1,15) = 8.789, p = .01) when compared to unilateral cNMES. Further, patients who are more severely impaired tended to show the greatest reduction in inhibition (r = .65, p = .006). Bilateral CCFES also prevented a decrease in corticospinal output originating from the ipsilesional hemisphere to the paretic upper limb witnessed otherwise with unilateral cNMES (-4.2±15% vs. -15.3±18%, F(1,6) = 9.16, p = .023). Last, there was a general trend for increased output from the uncrossed, ipsilateral output originating from the contralesional hemisphere to supply the paretic upper limb following bilateral CCFES when compared to unilateral cNMES (9.8±30.2% vs. 3.4±20.8%, F(1,15) = 3.177, p = .095). Our preliminary results suggest that the contralesional hemisphere may have a supportive influence upon movement of the paretic upper limb targeted uniquely using bilateral therapy. The contralesional hemisphere may alleviate inhibition imposed upon movement of the paretic upper limb and offer uncrossed, ipsilateral output to compensate for the loss of corticospinal output originating from the lesioned hemisphere.
The ability to grasp objects successfully under a variety of conditions is fundamental to numerous behaviors conducted during everyday life. Data from human and non-human primate studies converge on the role of multimodal parietal and premotor regions in visually-guided grasping. Despite its essential role in the control of grasp, cortical mechanisms involved in the integration of somatosensory information, including proprioception, have received considerably less attention.

We explored this issue through the use of a 2 x 2 factorial design, developing an apparatus that allows us to manipulate the availability of vision of the upper limb during one of two actions, either reach to touch or reach to grasp, in the fMRI scanner. Evidence from prior monkey neurophysiology work in area AIP has found evidence for grasp related cells which fire when vision of the upper limb and target are absent. We hypothesized that the anterior intraparietal sulcus (aIPS), the homolog to monkey area AIP, would show increased activity during the reach to grasp task with when no vision of the upper limb is available.

We were able to replicate previous fMRI studies of reach to grasp in humans while visual feedback is available, with the anterior intraparietal sulcus (aIPS) showing greater activation during grasp as opposed to reaching to touch without grasping. Further, our region of interest analysis found significantly greater activation in the aIPS when having to rely on non-visual feedback during grasping compared to when visual feedback was available, showing that the grasping network previously defined in human and non-human primate studies under vision indeed also incorporates somatosensory information. This is the first known attempt at exploring the effect of altered visual feedback of the upper limb and arm in humans using fMRI. Our results may help further develop our understanding of impairment following neurological insult and help in developing more effective rehabilitation strategies, possibly by manipulating vision as a means to increase activity in the grasp circuit.
**Introduction:**
Accurate and precise annotation of lesions is fundamental to investigating the relationship between brain, behavior, and recovery following stroke. Manual lesion segmentation remains the gold standard for lesion volumetry, yet this is often a labor-intensive process that requires domain expertise. A number of automated lesion segmentation approaches have been developed, but these approaches have not been systematically evaluated on a common dataset. Here, we aim to compare the accuracy of existing lesion labeling approaches on a common dataset with manually traced lesion masks to evaluate the performance of each approach.

**Methods:**
Here, we used T1-weighted anatomical MRIs from 12 individuals with chronic left hemisphere stroke (4 cortical; 8 subcortical). The same analyses will be performed on a forthcoming dataset of over 100 chronic stroke patients. Lesions were manually drawn in native space using MRICron, and their volumes (in mm$^3$) were obtained using `fslstats`. We employed three different automated lesion segmentation approaches: (1) tissue segmentation using an atypical tissue class prior and fuzzy clustering (Seghier et al., 2008, “ALI”), (2) voxel-based Gaussian naive Bayes classification (Griffis et al., 2016, “legion_gnb”), and (3) multi-resolution voxel-neighborhood random forest (Pustina et al., 2016, “LINDA”). To evaluate the similarity between the automated lesion segmentations and the expert labeling, we calculated a Dice overlap index (DI) for each automated segmentation. DI is determined as: $\frac{2|X \cap Y|}{|X|+|Y|}$, where $|X|$ represents the voxels in the expert segmentation and $|Y|$ represents voxels in the automated segmentation, and DI ranges from 0 (no overlap) to 1 (complete overlap). We conducted a Friedman Test to test for any significant differences in performance across the three approaches, and calculated a Spearman’s correlation on DI and lesion volumes to determine if segmentation performance was correlated with lesion volume.

**Results:**
There was a statistically significant difference in the DI among the three automated methods ($\chi^2(3) = 10.17, p = 0.006$). Median (IQR) DI were as follows: ALI=0.48 (0.37-0.67), lesion_gnb=0.43 (0.25-0.64), and LINDA=0.61 (0.53-0.79). Post-hoc analysis with Wilcoxon signed-rank tests (Bonferroni corrected significance level $p < 0.017$) showed that the median DI was significantly higher for LINDA than lesion_gnb ($Z=-2.35, p=0.016$). We found a positive correlation between DI and lesion volumes when using the LINDA approach ($r_s(10)=0.62, p=0.03$).

**Conclusion:**
We evaluated the performance of three different lesion segmentation approaches on a subset of T1-weighted stroke MRIs. We found that LINDA performed the best, and further, its performance changed along with the lesion volume. This suggests that lesion volume may be a possible confounding factor in subsequent analyses. In the near future, we will reevaluate these approaches on a larger dataset ($n>100$) to examine whether performance of different automated approaches is related to additional lesion characteristics such as lesion location and vascular territory.
Prior studies have suggested that displacements of the foot’s center of pressure (COP) can be used to gauge the individual’s relative sense of balance. In this study, we seek to replace conventional force platforms with a wireless single accelerometer system as a tool for measuring COP displacements. Study results indicated that accelerometer signals acquired from the waist (as compared to upper trunk and lower thigh) provided the lowest margins of error and the highest correlation between actual and estimated COP trajectories based on various different estimation algorithms (neural network (NN), genetic algorithm (GA), and adaptive network-based fuzzy inference system (ANFIS)). The results of our study are consistent with the fact that there is a high correlation between COP and the body’s center of mass (COM), which is close to the waist. Our study demonstrates the feasibility of using a single wireless accelerometer system programmed with algorithms to estimate COP excursions for clinical applications.
F28: Dynamic Modulation of Corticospinal Drive to the Plantarflexors Predicts Post-stroke Walking Function

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Purpose/Hypothesis
Current evidence reveals that only 50% of stroke survivors respond to rehabilitation targeting gait impairments. The presence of responders and non-responders among a cohort of rehabilitation candidates is unsurprising, yet the intrinsic physiologic characteristics that differentiate these groups of individuals remain unclear. Among prominent gait deficits following stroke, ankle plantarflexion (PF) is critical to producing forward propulsion, momentum, and limb advancement during swing phase. Here we whether gait function post-stroke is more strongly associated with corticospinal efficacy or modulation of corticospinal drive to the plantarflexors.

Subjects
We studied 34 adults: (13 healthy controls, mean age 61.7 (±8.5) years, 7 male), 21 stroke survivors, mean age (64.9 (±8.9) years, mean chronicity 82 (±58) months, mean LE FMA 25.8 (±7.2), 18 male).

Materials/Methods
We measured motor evoked responses (MEPs) generated by single-pulse TMS delivered during both isometric and dynamic ankle PF contractions. Participants were seated, positioned with the knee at 20-30º flexion and ankle at 0º PF. Single-pulse TMS was delivered over the ipsilesional (target) hemisphere using a custom Fig-8 coil (70mm diameter/wing) at 120% of resting motor threshold during isometric and dynamic PF contractions to assess corticomotor excitability and corticomotor modulation during dynamic effort. Stimulation location was determined by online evaluation of MEPs to maximize responses in the paretic (target) leg PFs (SOL, MG). Neuronavigation (BrainSight2) was used to track and maintain coil location. Participants generated PF torque between 10-20% of maximum voluntary contraction for 1 s which then triggered stimulations to occur while the ankle was held at (isometric), or moving through (dynamic), neutral position. Ankle PF power (A2), derived from inverse dynamics using data obtained separately during instrumented gait analysis, served as our primary outcome measure of gait function. SOL, MG, and tibialis anterior (TA) MEPs were manually identified and ensemble averaged (~10 repetitions per condition). MEParea was normalized to background EMG.

Results
MG MEParea during dynamic PF was significantly correlated with A2 (R = .463, p = .008) across both stroke and control groups. Stepwise regression using K-fold cross-validation (5 iterations) identified parameters predicting A2 magnitude in both stroke (.54011 +.0312 MGdynamic −.0031 Chronicity, R² = .675) and control (2.48 - .007 MGdynamic, R² = .21) groups.

Conclusions
Rather than corticospinal efficacy (i.e., MEP presence/absence), capacity to modulate cortical drive to the PFs during active movement predicts walking function post-stroke.

Clinical Relevance
Our data illustrate a strong relationship between corticospinal capacity and post-stroke walking function. Use of this approach for a priori identification of responders would substantively improve the efficacy and efficiency of rehabilitation by informing the development of interventions appropriately targeted towards: i) individuals with the capacity for recovery, ii) the most significant impairments, and iii) neural and biomechanical mechanisms with the potential for plasticity.
F29: Reaching from a Quadruped Position Involves an Anticipatory Weight Shift Between Arms

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Introduction and Background:
Although many behavioral tasks and activities require one to support partial body weight with the upper limbs, they have received little attention from basic and clinical researchers. Reaching from a quadruped position exemplifies this situation since it is mastered early in life and remains critical to certain contexts in adulthood, but is ignored relative to the analogous task of step initiation. Here we provide the first detailed examination of healthy subjects reaching from a crouched posture.

Methods:
Five right-handed males (age range 23-28 years old) participated in the study. Participants assumed a quadruped position with each hand placed on a separate force plate (AMTI-OR6). Surface EMG and movement kinematics were also obtained, which will be analyzed later. Subjects reached, grasped, and lifted a small cube with their left and right upper extremity in randomized order (40-60 trials total). The go-cue and reaching arm was indicated by a LED illuminated on the left or right side of the cube. Each block began with the subject placing their knees directly underneath their hips (a stable quadruped position), or placing their knees together (a less stable tripod-like posture). Normalized percentages for peak downward and upward forces were calculated.

Results:
Both conditions induced a consistent pattern of behavior across subjects. Similar to step initiation, subject exhibited a brief downwards force of the reaching arm, which allowed the transfer of body weight from two arms to one. In the knees together position, the peak downward force by the right and left arm was 18%, (±/ 11% SD), and 15%, (±/ 9% SD) of the steady downwards force prior to reaching with that arm. The stance arm also contributed to weight transfer through a brief unloading synchronized to the downwards pulse by the reaching hand. With the knees together, the peak unloading was 11% (±/ 11% SD) and 9% (±/ 15% SD) in the left and right arm, respectively. All of these anticipatory adjustments were attenuated when subjects reached from the more stable knees-apart posture; the peak downward force by the right and left arm was 7% (±/ 6% SD) and 6% (±/ 8% SD) with peak unloading of 3% (±/ 6% SD) and 2% (±/ 9% SD) in the opposing stance arm.

Conclusion:
Taken together, observations include: 1) robust postural shifts when reaching with the knees together, 2) greater postural shifts when reaching with the right arm compared to the left arm, and 3) weak postural shifts when reaching with the knees apart. The observed laterality and context-dependence of weight transfer from a quadruped posture is important for theories of motor function and will provide a baseline to understand compromised function in clinical populations such as Parkinson’s disease.
Mirror therapy is commonly used as a treatment for post-stroke hemiparesis. During mirror therapy, the participant places her unimpaired arm on the reflective side of the mirror and her impaired arm behind the mirror so that it is hidden. When the mirror is placed midway between the two limbs, movements of the unimpaired limb (viewed in the mirror) appear in the same location as the impaired limb. Thus, the mirror therapy setup creates a compelling illusion in which movements of the impaired arm behind the mirror appear to be made as effectively as the unimpaired arm. To date, it is unknown whether the subjective experience of the illusion is predictive of the therapeutic benefit of mirror therapy, or how this subjective experiences changes over the course of repeated mirror therapy sessions. To address these issues, we analyzed data from 41 chronic stroke survivors who completed up to 40 30-minute mirror therapy sessions over the course of 4 weeks. After each session, participants were asked to respond to the question “How much did it feel like the arm you saw in the mirror was actually your affected arm?” using a visual analogue scale. Overall, subjective rating of the illusion was weakly related to initial Fugl-Meyer (FM) score, with lower FM scores being associated with lower ratings of the subjective illusion. In addition, subjective ratings from the first mirror therapy session were not predictive of the improvement in FM score over the course of therapy. However, change in subjective rating over the course of therapy was associated with improvement in FM score. In summary, a lack of subjective experience with the mirror illusion need not be a deterrent to the use of mirror therapy for treating post-stroke hemiparesis.
F31: Resting State Cortical Oscillations Predict Dextrous Finger Improvements after Peripheral Stimulation

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Despite recent advances in rehabilitation, a substantial fraction of stroke patients continue to experience deficits especially in the ability to selectively individuate digits independently. Finger individuation is an important therapeutic target as it is commonly absent even after substantial recovery and may account for chronic dysfunction. Sensory threshold somatosensory electrical stimulation (SES) is a promising therapeutic modality for targeting hand motor recovery and is known to modulate sensorimotor cortices. Devices such as transcutaneous nerve stimulation (TENS) can deliver SES, are low-risk, inexpensive and suitable for a home setting. In addition, it should be noted that SES does not always result in positive outcomes. To this end, Electroencephalography (EEG) is a low-cost, real-time method to obtain neural biomarkers associated with SES efficacy. The two concurrent goals of this study was to a) evaluate the efficacy of SES on finger fractionation and b) characterize the neural biomarkers associated with motor responses to SES intervention. Eight participants with a 6-month or greater history of acquired brain injury and distal upper limb motor impairment received a single two-hour session of submotor/suprasensory threshold stimulation using a transcutaneous electrical nerve stimulation (TENS) unit applied to the median, ulnar, and radial nerves simultaneously. Pre- and post-intervention assessments consisted of the Action Research Arm Test (ARAT), finger fractionation, pinch force, and the modified Ashworth scale (MAS), along with resting-state EEG monitoring. Consistent with prior studies, PNS was associated with statistically significant improvements in the ARAT and MAS. For the first time, finger fractionation was demonstrated to improve significantly after PNS, along with a relative decrease in ipsilesional parietomotor EEG power, in individuals with acquired brain injury. In addition, we found striking changes in the average EEG pattern for responders versus non-responders. Ipsilesional theta and alpha power changes were significant predictors of finger fractionation restoration when using a multivariate model of resting-state dynamics and the effects on motor behavior. These results suggest that cortical oscillations may be an important electrophysiological biomarker of individual responsiveness and may be a useful target for customizing PNS parameters to the individual with loss of distal hand function after acquired brain injury.
F32: Bimanual Use in Chronic Stroke Survivors with Left or Right Hemiparesis is Differentially Influenced by Non-Paretic Arm Function

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Introduction.
Despite growing evidence pertaining to arm use after stroke, little is known about how stroke survivors solve ecologically relevant bimanual tasks. The purpose of this study was two-fold: 1) to identify volitional arm use patterns adopted for symmetric and asymmetric bimanual tasks and to compare these use patterns between left (LHP) and right-hemiparetic (RHP) individuals, 2) to determine if single-limb (paretic and non-paretic) measures of functional performance can be used to classify the observed bimanual task use patterns.

Methods.
50 pre-morbidly right-handed stroke survivors with Upper Extremity Fugl-Meyer (UEFM) 42 ± 10, (i.e., 25 RHP) performed two different bimanual tasks (items from the Actual Amount of Use Test). Arm use patterns were classified, first by whether one or both arms were used (i.e., unimanual or bimanual), and second by the nature of paretic arm use (i.e., primary or secondary controller). Logistic regression was performed to analyze the effect of the level of motor impairment, side of paresis, and task demand. Next, to classify observed use patterns based on single-limb functional performance, time-scores from the distal component of the Wolf Motor Function test (WMFT) for each arm for 37 of the 50 individuals were log transformed (i.e., natural log, ln) and used as classifier variables. The area under the curve (AUC) of the receiver-operator curve (ROC) was used to determine the robustness of the classification of use (i.e., unimanual or bimanual).

Results.
First, individuals with more severe impairment (UEFM < 41) and those with LHP were less likely to choose a bimanual use pattern for either of the bimanual tasks (B = 14.64, p< 0.001). For the asymmetric task, probability of bimanual use was greater in the RHP compared to LHP group, especially in the more severely impaired; whereas, for the symmetric task, this difference was observed only in the less severely impaired (B = -1.45, p< 0.001). Second, the ROC analysis revealed that paretic arm ln-WMFT time-score was a good classifier of use patterns (i.e., unimanual or bimanual) for both LHP (AUC = 0.79) and RHP (AUC = 0.80) groups. Conversely, the ln-WMFT time-score for the non-paretic arm was an excellent classifier of use patterns only for the RHP (AUC = 0.85), but not the LHP group (AUC = 0.55).

Conclusions.
Chronic stroke survivors with left arm paresis (non-dominant) were less likely to spontaneously choose bimanual use patterns, whereas those with right arm paresis (dominant) were more likely to choose to use the two hands together to solve bimanual tasks. Whether a unimanual or bimanual pattern was chosen could be classified by the functional performance of the non-paretic arm, but only in individuals with right arm paresis. Secondary analyses were performed to explore the relationship between paretic and non-paretic arm performance and explain the apparent discrepancy between left and right hemiparetic groups.
Background:
Upper extremity paresis, common in many neurological conditions, is a major contributor to long-term disability and decreased quality of life. Evidence shows that repetitive, bilateral arm movement improves upper extremity coordination after neurological injury. However, it is difficult to integrate upper extremity interventions into very early rehabilitation of critically ill neurological patients due to patient arousal and medical acuity. This report describes the safety and feasibility of bilateral upper extremity cycling in critically ill neurological patients with bilateral or unilateral paresis.

Methods:
Patients were included into this observational series if they used upper extremity cycle ergometry with occupational therapy while in the neurocritical care unit between May and August 2016. Patient demographics, neurological function, and hemodynamic status were recorded pre and post cycling. Cycling parameters including duration and active and/or passive cycling were collected.

Results:
Thirteen bilateral UE ergometry sessions were completed with six critically ill patients. The mean age of participants was 67.7 (+ 12) years and 2/6 (33%) subjects were female. Four patients were diagnosed with stroke, one with brain tumor, and one patient with encephalitis. Two patients were mechanically ventilated and three patients had external ventricular drainage devices in place during cycling sessions. Patients performed bilateral UE cycling with both passive and active mobility settings. The majority of sessions began with passive cycling 11/13 (85%) and 8/13 (62%) sessions included active cycling. Median UE cycling time was 15:05 (range 9 min to 25 min 43 seconds). There were no significant changes in hemodynamic or respiratory status during cycling sessions. Median MAP decreased by 5 mmHg (+ 6.8) with median systolic blood pressures decreasing by 14.5 mmHg (+ 10.7). No hemodynamic, oxygenation nor intracranial pressure values varied outside of prescribed ranges during or immediately after cycling. Arousal level and command following pre and post intervention were unchanged during all trials. No safety issues in terms of device dislodgement, pain, or change in the neurological status were observed.

Conclusions:
In this series, upper extremity cycle ergometry was a safe and feasible intervention for early rehabilitation in critically ill patients in the neurocritical care unit. Future studies will prospectively measure the impact of early upper extremity cycle ergometry on neurological recovery and functional outcome in this population.
F34: The Impact of a Single Session of Physical Activity on Cognitive Function in Chronic Stroke Survivors

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Emerging evidence suggests that cognitive function improves immediately, following a single bout of aerobic exercise, in children as well as young and older adults. Cognitive impairment contributes to significant functional disability in survivors of stroke, negatively impacting mobility, communication, and the ability to care for self and others. The potential for an acute bout of exercise to confer benefit for cognitive function has not been systematically investigated in this population. This study examined the impact of an acute bout of moderate intensity aerobic exercise compared with non-aerobic stretching on various domains of cognitive function in individuals with chronic stroke. METHODS: 12 Chronic (> 6 months) stroke survivors (6 females) and 13 age-matched healthy controls (6 females), completed a single 20 minute session of moderate intensity aerobic exercise and a time-matched bout of non-aerobic stretching, approximately one week apart (counter-balanced by random ordering). Average age of both stroke and control samples are 61.8 (+/- 9.4). Global index along with domain-specific scores that include memory, attention, information processing speed, visual-spatial processing, and motor skills were assessed before and after each test session using a computerized neuropsychological battery (NeuroTrax™) with strong psychometric properties. RESULTS: Stroke participants displayed reduced global cognitive function, compared with age-matched healthy participants, prior to engaging in physical activity but were no different than the healthy controls after either type of physical activity, significant Time x Group interaction, f(1,23) = 9.23, p < .01. This same relationship was observed for the domain of attention, significant Time x Group interaction, f (1, 20) = 5.88, p < .05. A main effect for time in Memory (f (1, 23) = 7.37, p < .05) and visual-spatial processing (f (1, 23) = 6.03, p < .05) improved for both participant groups after either type of physical activity. CONCLUSION: Regardless of type of exercise (aerobic or non-aerobic stretching), structured physical activity improves global cognitive function of individuals with stroke to comparable levels seen in healthy adults immediately following physical activity. These data suggest that an acute bout of physical activity may prime survivors of chronic stroke to derive more benefit from subsequent rehabilitation tasks with cognitive demands.
Introduction:
Hemiparesis after stroke is one of the leading causes of disability in the United States. How the motor networks reorganize after stroke has yet to be fully elucidated and, with the advent of non-invasive brain stimulation as a potential adjuvant to stroke rehabilitation, it is imperative to identify the most beneficial neural sites to target for enhancing recovery. In a previous study, we identified that nonlesioned dorsal premotor cortex (nlPMd) has a functionally relevant role during reaching in patients with severe hemiparesis. In the intact motor system, the dominant hemisphere is thought to influence both arms to a greater extent than the nondominant hemisphere. In this analysis, we aimed to determine whether the role of nlPMd differed between patients with dominant vs. nondominant hemisphere stroke.

Methods:
Using transcranial magnetic stimulation (TMS), we examined how perturbation of nonlesioned hemisphere [PMd and primary motor cortex (M1)] during a reaching reaction time task affected reaching performance. TMS (double-pulse; ISI 25 ms; 120% of resting motor threshold for unaffected biceps) was delivered over M1 or PMd of the nonlesioned hemisphere during the reaction time period between the ‘Go’ signal and the onset of the reaching movement.

Results:
26 right-handed individuals with chronic stroke participated in the study (13 left and 13 right hemisphere affected. In a 2x2 mixed model ANOVA of nlPMd recruitment, there was a significant interaction effect of hemisphere affected(F(1,24) = 4.5, \(p=0.044\)) demonstrating that patients with left-hemisphere strokes showed greater recruitment of nlPMd than nlM1.

Conclusions:
In all patients in our sample, no matter the level of severity, patients with lesions in the left hemisphere demonstrated greater functionally-relevant recruitment of nlPMd. These results suggest that lesion location should be considered when determining target selection for non-invasive brain stimulation.

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Spasticity is one of the most common symptoms in humans with spinal cord injury (SCI). The neurophysiological and behavioral outcomes related to its clinical assessment, however, remain poorly understood. Here, we examined the Modified Ashworth Scale (MAS; a gold standard clinical assessment of spasticity), the Wartenberg’s Pendulum Test, and the maximal H-reflex (H-max) and motor response (M-max) in the quadriceps muscle in individuals with SCI who had residual voluntary activity (incomplete SCI, n=18) and in those unable to voluntarily activate muscles below the level of injury (complete SCI, n=18). We found that the MAS was higher in individuals with incomplete (2.34±1.15, p<0.001) compared with complete (0.76±0.74) SCI. The H-max and M-max were larger in individuals with incomplete compared with complete SCI and control subjects. The knee joint angular velocity was less pronounced in individuals with incomplete compared with complete SCI, suggesting that individuals with incomplete SCI had more pronounced spasticity. To further understand the physiological mechanisms contributing to spasticity in individuals with complete SCI who showed spasticity (MAS=3) and no spasticity (MAS=0) we examined the integrity of the corticospinal pathway by using transcranial magnetic and electrical stimulation over the leg motor cortex and measuring motor evoked potentials (MEPs) in the quadriceps muscle. Notably, we found that MEPs elicited by magnetic and electrical stimulation were present in individuals with complete SCI who had severe spasticity but absent in individuals with complete SCI without spasticity. Altogether our results suggest that transmission in the corticospinal pathway contributes to spasticity in humans with chronic incomplete SCI.
Objective:
This study is part of a larger clinical trial that investigated whether higher doses of task-specific training in chronic post-stroke resulted in better motor outcomes than lower doses. Here, we studied the effect of dose on changes in white matter after therapy using measures of diffusion tensor imaging (DTI) in transcallosal fibers.

Methods:
Eighty-five participants with chronic stroke were randomly assigned to one of four dose groups: 3,200, 6,400, 9,600, or individualized maximum repetitions during 1h of task-specific upper-limb training. The training was performed 4 days/week during 8 weeks. A subset of these patients (N=32) underwent DTI scans before and after training. Values for fractional anisotropy (FA) and mean diffusivity (MD) within the body of the corpus callosum (CC) were extracted using a region of interest-based analysis with the FMRIB Software Library (FSL). The clinical outcome measure was the change in the Action Research Arm Test (ARAT). ANOVAs tested the effect of dose on changes (Δ) in FA, MD, and ARAT. Independent t-tests were used for group comparisons.

Results:
Dose had no significant effect on either the amount of change of the DTI-measures in transcallosal fibers (ΔMD: \( p=0.605 \), and ΔFA: \( p=0.786 \)) or on ΔARAT from the 32 participants with imaging data (\( p=0.636 \)). Subgroup analyses investigated two additional questions. The first analysis asked if changes in DTI-measures due to training would differ in Responders (ΔARAT ≥ 9 points) compared to Non-responders (ΔARAT ≤ 2). After training, ΔMD was negative for Responders and positive for Non-Responders [-0.042 ± (SE) 0.028 vs. 0.022 ± 0.013 \( \mu m^2/s \), \( p=0.031 \)]. The second analysis asked if changes in DTI-measures after training would differ in individuals with stroke affecting their Dominant (N=21) vs. their Non-dominant (N=11) hand. ΔMD was negative for the Dominant and positive for the Non-Dominant group [-0.016 ± (SE) 0.010 vs. 0.024 ± 0.013 \( \mu m^2/s \), \( p=0.029 \)]. Also, the increase in ΔARAT was larger for the Dominant than for the Non-Dominant group [6.38 ± 1.23 vs. 2.09 ± 3.45, \( p=0.029 \)]. Mean ΔFA values were not different between groups.

Interpretation:
Even though training was associated with small improvements in motor outcome, there was no effect of training dose on either ΔDTI-measures or on ΔARAT. Individuals with larger response to training, and with stroke affecting their dominant hand had a decrease in MD values post-training; while those with a smaller response to training and with stroke affecting their non-dominant hand had an increase in MD values. These observations may suggest that the importance of interhemispheric connections varies depending on whether the dominant or non-dominant hand is trained.
Background/Objectives:
In children with unilateral spastic cerebral palsy (USCP), descending motor pathways and ascending sensory tracts present structural abnormalities. The relationship between the integrity of these pathways and sensorimotor function was examined.

Participants:
25 children with USCP (13 males, age 9.1±3.1y).

Methods:
We used diffusion tensor imaging (DTI) tractography to visualize corticospinal tracts (CST), somatosensory tracts (SST), and posterior thalamic radiations (PTR). Scans were acquired with a 3T Siemens magnetic resonance imaging scanner, with a DTI protocol using 65 directions. Regions of interest to seed and visualize the tracts were identified using a novel, validated, automated brain segmentation based on a Multiple Atlas Likelihood Fusion (MALF) algorithm (MRICloud). The following DTI parameters were evaluated for each tract in the affected and unaffected hemispheres: number of fibers, fiber volume, and tract-based fractional anisotropy (FA). Dexterity of each child was evaluated using the Jebsen-Taylor Test of Hand Function (JTTHF) and the Box and Blocks test (BBT). Sensory ability was examined using the Cooper Stereognosis test and Two-Point Discrimination test (TPD).

Results:
We found significant differences between the affected and unaffected hemispheres for number of CST fibers, fiber volume, and tract FA (p<0.01 for all measures) and significant differences between the affected and unaffected hemispheres for number of SST fibers and fiber volume (p<0.01 for both) but not tract FA. There were no differences between the two hemispheres for any of the DTI parameters for PTR (p>0.05). We also found a significant association between the number of fibers in the affected hemisphere and dexterity (Pearson, r=-0.51 [CI: -0.75 - -0.14], p<0.001 for JTTHF and Pearson, r=0.63 [CI: 0.31 - 0.81], p=0.001 for BBT). Greater number of CST fibers from the affected hemisphere was associated with better dexterity. Similar associations were found between dexterity measures and CST fiber volume and FA. We did not observe any significant correlations between SST or PTR measures and sensory function. We did, however, find a significant relationship between number and volume of SST fibers and dexterity (Pearson, r=-0.43 [CI: -0.04 - 0.71], p<0.05 for number and Pearson, r=0.46 [CI: -0.07 - 0.713, p<0.05 for volume). To evaluate the relationship between integrity of CST and SST on dexterity, a multiple regression was performed. We found that CST, but not SST, integrity drove the significant association between FA and dexterity, F(2,21)=5.74, p<.05, R²=0.35.

Conclusion/Significance:
These findings provide further evidence for the relationship between the integrity of descending motor pathways and dexterity. Although we did not find significant relationships between ascending sensory pathways and sensory function, sensory pathway integrity was related to dexterity. These neuroimaging findings provide deeper insights into the relationship between neuroanatomical characteristics and behavioural measures of hand function in children with USCP.
F39: Restoration of Distal Upper Extremity Motor Function with a Brain-Computer Interface Therapy

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Introduction:
This sub-analysis of a larger, on-going clinical trial (NCT02098265) evaluates effects of an interventional, non-invasive electroencephalographic (EEG) based brain-computer interface (BCI) therapy for restoration of distal upper-extremity (UE) motor function in stroke survivors.

Materials & Methods:
In this crossover control design, interventional impacts of 9-15 BCI rehabilitation therapy sessions in 29 stroke survivors (n=14 delayed therapy group (DTG), n=15 immediate therapy group (ITG), mean age= 62 years, n=12 female) were measured at 4 time points using the Action Research Arm Test (ARAT) as a primary outcome measure, the Nine-Hole Peg Test (9-HPT), patient reported outcome measures of activity: Stroke Impact Scale (SIS), Motor Activity Log (MAL). Likelihood ANOVA testing of Linear Mixed Effects (LME) models with fixed (age, chronicity, severity, concordance, gender, condition (intervention vs. control period), time) and random (subject intercepts) effects tested for group-time interactions in outcome measures. Participants presenting with ceiling or floor effects were excluded from analyses of those measures; treatment responders were identified by Minimal Clinically Important Difference (MCID).

Results:
Time in intervention, as a fixed effect for all subjects, influences outcome scores (ARAT n=25, p=0.00044, SISMobility n=28, p=0.000091, SISHand-Function n=22, p=0.049, SISADL n=29, p=0.042, SISStrength n=29, p=0.00063, MALAS n=34, p=0.00092, MALHW n=21, p=0.00038).

Testing for significant interactions between time and condition were positively correlated for: SISMobility (p=0.02), SISADL (p=0.0077), SISStrength (p=0.033), and MALAS (p=0.046). Among these measures, ITG improved over therapy more than DTG improved over the delay.

Analysis of DTG participants, taking into account all fixed effects in the LME model, showed a change in predicted ARAT score (p=0.00044) when using likelihood ANOVA to assess effect of time in therapy

Though treatment effects over time increased through therapy, few individual participants achieved MCID in (ARAT n=3, SISMobility n=16, SISHand-Function n=5, SISADL n=12, SISStrength n=13,) outcome measures where MCID is established.

Conclusion:
BCI therapy improves behavioral participation in activities of daily living (ADLs), particularly in patient reported measures, compared to normal and customary (delayed therapy) care. It is possible that objective observational assessments (ARAT and 9HPT) chosen do not capture the extent to which BCI driven functional improvements impact a participant’s real world capacities. The mechanism(s) of action and deliverable benefits of BCI as an interventional therapy may not only be improvements in functional assessments but perhaps also an increased ability or willingness to participate in ADLs.

More research into the cognitive and psychomotor implications of BCI interventions are needed to understand relationships between neurobiological changes and functional improvements.
F40: Safety and Tolerability of Transcranial Direct Current Stimulation in the Subacute Phase after Stroke

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Introduction:
Hand paresis occurs in up to 85% of the patients after stroke, a common and often disabling condition. Transcranial direct current stimulation (tDCS) is a noninvasive neuromodulation intervention with potential to improve functional motor outcomes in patients with stroke, particularly in the chronic phase. Studies about effects of tDCS administered within the first weeks after stroke are still scarce.

Objective:
To evaluate safety and preliminary efficacy of active cathodal tDCS of the motor cortex of the unaffected hemisphere compared to sham tDCS, in patients in the subacute phase after stroke.

Methods:
In this randomized and double-blind study, 40 patients presenting unilateral hand paresis within 72 hours to 6 weeks post-ischemic stroke are randomly assigned to either active or sham tDCS over the primary motor cortex, followed by physical therapy for one hour three times a week, for two weeks. Adverse events are monitored during and after the interventions. Blinded evaluators assess secondary outcomes at baseline, after the end of treatment and 3 months later: Fugl-Meyer Assessment score for the upper limb (FMA), upper limb motor score of the National Institutes of Health Stroke Scale (NIHSS), Motor Activity log (MAL), Modified Ashworth Scale (MAS), total score of the National Institutes of Health Stroke Scale (NIHSS), Modified Rankin Scale (mRS), Barthel Index (BI), Stroke Impact Scale (SIS), Montreal Cognitive Assessment (MoCA) and Pittsburgh Sleep Quality Index (PSQI). Magnetic resonance images were performed before and after treatment to evaluate volume of the infarcts and search for new lesions. Secondary safety outcomes are evaluated at baseline and after the end of treatment.

Results:
We presented data of 20 patients recruited until this moment. Overall, tDCS was well tolerated. 90% of the patients in the active group and 100% in the sham group reported mild adverse events such as paresthesias under the anode, expected to occur during active stimulation and within the first 30 seconds of sham stimulation. There were no serious adverse events. There was no deterioration in performance in secondary outcomes in either active or sham groups. There were no new ischemic lesions in the active or sham groups.

Discussion:
Mild adverse events in this study were already related in the literature and were similar between both groups. In contrast with results from animal studies, we did not observe new ischemic lesions after active cathodal tDCS.

Conclusion:
The study is ongoing. Our preliminary results suggest that cathodal tDCS of the motor cortex of the unaffected hemisphere is safe in patients in the subacute phase after stroke.
F41: Frequency Domain Analysis of Fugl-Meyer Assessment Data in Individuals Post Stroke

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Background:
Sensor based measures of impairment may provide insight into the evolution of motor recovery after the onset of stroke, as it develops outside of the clinical setting. In past work, the authors found that frequency domain analyses of upper extremity sensor data were sensitive to levels of motor impairment in unstructured activities of daily living (ADLs) performed by individuals post-stroke. The utility of such an approach is it may overcome challenges of gesture recognition in the types of continuous sensor data necessary for in home monitoring.

Objective:
The aim of this study is to investigate the sensitivity of frequency domain features to impairment as measured by the structured Fugl-Meyer Assessment (FMA). We hypothesized that frequency domain features would differ between limbs and be differentially predictive of impairment, as measured by a multiple linear regression analysis.

Methods:
Seven participants (66±18 years, 2M/5F) in the sub-acute phase of stroke recovery wore APDM inertial measurement unit (IMU) sensors on their wrists, upper arms, and torso. Participants performed gestures from the FMA, administered by a trained physical therapist. Triaxial accelerometer data from individual gestures were manually segmented using synchronized video data. Custom MATLAB scripts were used to automate the selection of gestures, filter the data through a second-order low bandpass filter, and extract frequency domain features. A previously utilized frequency domain feature, the relative power in various frequency bands (0.1-1Hz, 1-2Hz, and 2-10Hz) of accelerometer data, was calculated for each gesture, and for both limbs. Multiple linear regression was used to investigate the predictive ability of the frequency domain measures for the gesture duration separately for the paretic and non-paretic limbs. First, a search was performed to determine the most appropriate regression model using various combinations of frequency bands and sensor axes. Next, the performance of this model was evaluated across a subset of gestures from the FMA. Finally, the behavior of the corresponding coefficients for the paretic and non-paretic limbs were compared.

Results:
For both the paretic and non-paretic limb, a regression model using a single frequency domain measure from each of the x-, y-, and z-axes of data was significantly predictive of gesture duration (residual error of 3475, r²=0.697 for paretic limb residual error of 2307, r²=0.765 for non-paretic limb). Coefficients corresponding to power in the 1-2Hz frequency band switch sign between the paretic and non-paretic limbs (positive for non-paretic, negative for paretic).

Conclusions:
Given the differences in the frequency band of 1-2Hz which typically captures volitional motion, these results suggest this feature may be a sensitive measure of impairment in both structured (FMA) and unstructured (activity of daily living) tasks. Future work will investigate the extent to which this feature evolves over time in response to a therapeutic intervention.
F42: Mirror Movements: What do They Mean for Recovery of the Paretic Upper Limb in Stroke?

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Background and Objective:
Patients with stroke commonly exhibit mirror movements. Mirror movements can make it challenging to draw interpretations about recovery, based on functional MRI. Typically, severely impaired patients show over-activation of contralesional motor cortices during movement of the paretic hand. But since these patients also show substantial amounts of mirror movement in the non-paretic hand, it becomes difficult to disentangle whether contralesional over-activation is associated with mirror movements or recruitment of undamaged resources to assist in movement of the paretic hand. What is also unclear is why these patients exhibit mirror movements. Here, we investigated how mirror movements affected the relationship between fMRI activation and impairment, and the neurophysiologic bases for their origin.

Methods:
Twenty-five patients with chronic stroke underwent fMRI and Transcranial Magnetic Stimulation (TMS). During fMRI, patients performed phasic flexion-extension movement of paretic fingers, while mirror movements were recorded using kinematic gloves. Mirror movements were also recorded during sustained, tonic contraction of the paretic first dorsal interosseus (FDI) muscle. TMS was used to measure trans-callossal inhibition and excitation of ipsilateral pathways.

Results:
Our research sample consisted of mild-to-moderately impaired patients (Upper Extremity Fugl-Meyer scale: mean (± s.e.m.) 43.6±2.75). Patients showed considerable amounts of mirror movement during phasic motion (p=0.05) and tonic contraction of the paretic hand (p=0.002) than the non-paretic hand. Patients with severe impairment showed more mirror movements (r= 0.71, p< 0.001). They also showed over-activation of the contralesional primary motor cortex, premotor cortex and cerebellum [(r= 0.518, p= 0.016), (r=0.471, p=0.027) and (r=0.495, p=0.019), respectively]. But when mirror movements were included in the model, the relationship between impairment and activation became non-significant for the primary motor cortex, and remained significant for the premotor cortex and the cerebellum. Neither trans-callossal inhibition imposed from the ipsilesional motor cortices nor ipsilateral pathways from the ipsilesional hemisphere could explain mirror movements in the non-paretic hand. Ipsilateral pathways from the contralesional hemisphere, however, were evidenced in moderate-to-severely impaired patients, who showed considerable amounts of mirror movements (χ² =7.9, p =0.005).

Conclusions:
Therefore, over-activation of the contralesional primary motor cortex is mainly related to mirror movements, whereas over-activation of the premotor cortex or the cerebellum may be indicative of the role played by these regions in supporting movements of the paretic upper limb. Cautious interpretation of activation in the primary motor cortices is thus warranted. Mirror movements do not appear to originate based on trans-callossal or ipsilateral influences; spinal mechanisms should be considered. What is intriguing however is the evidence of ipsilateral pathways to the paretic upper limb in severely impaired patients who show considerable amounts of mirror movement. Mirror movements may thus reflect the supportive role played by the contralesional motor cortices in recovery of more impaired individuals.
It has been suggested that maladaptive changes in the motor cortex exaggerate muscle weakness and limit recovery following incomplete spinal cord injury (iSCI). Specifically, immediately after iSCI the motor cortex begins to lose cortical representations of weaker muscles while those of stronger, more spared segments magnify. Here we aimed to reverse such maladaptive changes and rather boost inherent adaptive plasticity of weak representations using transcranial direct current stimulation (tDCS). We hypothesized that tDCS would ultimately maximize functional outcomes following rehabilitation via increases in weak muscle cortical representational plasticity and excitability of their descending pathways. To test our hypothesis, fourteen subjects with chronic iSCI received either upper limb rehabilitation with tDCS (2 mA anodal) to motor cortical representations of weak muscles or sham tDCS with rehabilitation for 5 days/week for 2 weeks. From pretest to posttest, we monitored changes in cortical plasticity using transcranial magnetic stimulation (TMS). We determined the change of cortical representations devoted to muscles both caudal and rostral to the lesion. We also quantified sparing of descending tracts using diffusion tensor magnetic resonance imaging (DTI). Finally, we assessed functional measures at pretest, posttest and three months follow-up. Functional measures included: upper extremity motor score, action research arm test, manual muscle testing and nine-hole peg test. A linear mixed methods model was used for analysis, where significance was defined as p<0.05.

We found that subjects who received tDCS+rehabilitation, in comparison to sham, had more notable increases in muscle strength (improved medical research council (MRC) grade) for C5-T1 myotomes. Advantages for the muscle MRC grade were also found across forearm, hand and thumb for the tDCS+rehabilitation group (improved MRC grade of 1 level more). Improvements in muscle contraction were related to plastic changes in the brain. Specifically, subjects in the tDCS+rehabilitation group demonstrated (1) a more focal representation of a weaker muscle located below the level of injury (by 20%) and (2) a significant shift of the representation of a stronger muscle located above injury (~12 mm; p<0.05). In addition, level of recovery was related to cortical tract integrity, wherein subjects that demonstrated the most recovery had greatest tract sparing following their iSCI (r=0.97; p<0.0001). Our findings suggest that tDCS+rehabilitation may be an effective technique to improve muscle strength in paralyzed/weak muscles by alleviating maladaptive changes in the brain. Further, descending tract integrity, as measured with DTI, may serve as a valuable prognostic marker of impairment and functional recovery potential.
F44: Promoting Walking Recovery through Patient-Directed, Autonomous Task-Related Practice during Inpatient Stroke Rehabilitation: A Feasibility Study

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Background:
Maximal recovery of walking after stroke depends on abundant, progressive task-oriented practice. In rehabilitation, opportunities for practice are often restricted to supervised therapy sessions. This approach can create a dependence on therapist supervision, and limit the likelihood of ongoing walking-related practice, and recovery, when discharged to the community. There is need for research into interventions that promote practice during the many hours patients spend inactive, outside of formal therapy sessions.

Purpose:
To describe the Independent Mobility and Physical ACTivity (IMPACT) program and present results of a recent pilot study.

Design:
Prospective pilot study with a 9-month control period (n=18) followed by a 5-month intervention period (n=15). During the control period, participants received standard stroke rehabilitation care. During the intervention period, patients were encouraged to engage in autonomous walking-related practice in addition to standard rehab care by a physical therapist trained in the IMPACT program.

IMPACT program:
The aim of the IMPACT program is to increase the amount of walking-related practice patients undertake during rehabilitation, and develop skills necessary for ongoing self-management of their mobility-related rehabilitation when discharged into the community. This program is rooted in self-determination theory and motor learning research, and incorporates elements of chronic disease self-management approaches. Under the guidance of the therapist-coach, patients set walking-specific goal(s), develop a task-related practice plan, and implement, self-monitor, and modify the plan as appropriate. Walking-related practice is to be carried out independently and/or with family outside of, and in addition to, supervised therapy sessions.

Outcomes:
Recruitment and retention, completion of intervention, time to first independent mobility practice, and daily step activity (Actigraph G3TX).

Results:
Recruitment rate was 2.0/month for the control period and 3.1 for the IMPACT period. Control participants were 72.5 (SD 10.0) years of age, 16.8 (11.5) days post-stroke and had a FIM of 77.1 (14.1) at baseline. IMPACT participants were 73.4 (15.8) years, 12.9 (5.7) days post-stroke, and had a FIM of 73.5 (16.7). Four participants were not assessed at discharge (Control n=2; IMPACT n=2). All remaining IMPACT participants completed the key intervention activities (i.e. goal-setting, development, implementation and self-monitoring of a walking-related practice plan). Walking activity: Time to first independent walking-related practice was 7.5 (1.6) days during the control period, and 1.6 (1.4) days during the IMPACT period. Control participants took 3139 (2040) steps/day, while IMPACT participants took 4613 (2033) steps/day (p=0.20).

Conclusions:
The IMPACT program to self-directed walking rehabilitation was found to be a feasible approach in an inpatient stroke rehabilitation unit. Implementation of the IMPACT program was associated with a trend towards earlier and increased walking activity during rehabilitation compared to standard care. These encouraging results will inform the design of a multisite cluster randomized controlled trial.
F45: Myoelectric Computer Interface Training to Improve Arm Movement after Stroke

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Impaired arm function after a stroke is caused by not only weakness, sensory impairment, and spasticity, but also by abnormal co-activation patterns of arm muscles. We have designed a paradigm that uses a myoelectric computer interface (MCI) game to help stroke survivors reduce this abnormal co-activation. The MCI maps the activity of a pair of abnormally-coupled muscles to orthogonal components of cursor movement in the game, and the user learns to decouple the muscles by moving the cursor to targets along the mapping directions. We evaluated the effects of in-laboratory training for over 18 sessions in 30 chronic stroke survivors. We compared the effects of training duration (60 vs. 90 minutes per session) as well as isometric vs. movement-based training conditions, for a total of 3 subject groups. We measured the degree of co-activation, arm joint kinematics, and clinical outcome metrics. All subject groups were able to reduce abnormal co-activation in targeted muscles using the MCI training. Each group showed a trend of reduced arm impairment after 6 weeks of training—Fugl-Meyer Assessment, improvement of 3.4±2.8 (mean±SE) for 60-min. group, 3.8±3.6 for 90-min. isometric group, and 3.5±3.4 for the 90-min. movement group). MCI training also improved subjects’ arm function as measured by the Wolf Motor Function Test (−4.0 s, −7.8 s, and −6.9 s for the 60, 90, and isometric groups, respectively) and Motor Activity Log (3.9, 5.5, and 1.2 point gains for the 3 groups). Overall, there was a trend to improved function with longer training; no statistical difference was seen between movement-based and isometric training. Moreover, the gains persisted at one month after training stopped.

We are currently investigating a wearable version of the MCI and testing whether more frequent training, in the home setting, will translate to even greater gains in arm function. If successful, this paradigm could ultimately synergistically help patients undergoing more traditional rehabilitation, as well as those who have completed physiotherapy.
F46: Interactions between Posture and Locomotion in Nonimpaired and Poststroke Walking

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Background:
Slow walking speeds exhibited by individuals poststroke are related to reduced propulsion and associated misdirected, sagittal resultant ground reaction forces (GRFs) during late stance. These misdirected forces may be explained by excessive influence of brainstem-involved postural control pathways over locomotor control pathways.

Purpose:
Determine the effects of minimizing postural demands of walking on GRF direction for nonimpaired and individuals poststroke. We expected that nonimpaired individuals would appropriately direct GRFs during late stance across varying levels of body-weight support (BWS); however, that GRF direction would be altered when we minimized postural demands. In contrast, we expected individuals poststroke would misdirect GRFs when walking with typical postural demands, but that GRF direction would be more similar to nonimpaired when walking with minimal postural demands.

Methods:
We fabricated a postural support apparatus that provided external support of upright orientation and full support of upper body and trunk mass during walking. Five nonimpaired (33-62 years) and five individuals poststroke (26-66 years) walked in two conditions over a treadmill, 1) typical postural demands (TYP), and 2) minimal postural demands (MIN), in the apparatus, with matched vertical GRFs achieved through an intentional “push” against the moving treadmill belt. Nonimpaired individuals walked at two speeds (0.5m/s and 1.0m/s), while individuals poststroke walked at their comfortable speed (M=0.56m/s ± 0.29). The TYP condition included four trials with different magnitudes of vertical GRF (i.e., 100%, 90%, 80%, 70% body weight). The MIN condition included four trials targeting vertical GRFs derived from forces during TYP walking. We investigated average sagittal resultant GRF direction (i.e., fore-aft (Fy)/vertical (Fz)) from 50-75% of the stance phase across force levels for each condition. We analyzed the dominant limb of nonimpaired, and both limbs for individuals poststroke. We compared average Fy/Fz between groups using independent t-tests, and between conditions within groups using paired t-tests.

Results:
We found no significant difference in Fy/Fz between the nonimpaired and nonparetic limbs during TYP walking at any force level (p=0.12 – 0.96); however, Fy/Fz significantly differed between the nonimpaired and paretic limbs (p=0.03 – 0.05). In contrast, during MIN walking, we found significantly different Fy/Fz between nonimpaired and nonparetic (p=0.002 – 0.05), and nonimpaired and paretic limbs (p=0.001 – 0.04). Within groups, Fy/Fz significantly differed between TYP and MIN walking for nonimpaired individuals at both speeds (p=0.01 – 0.05); however, Fy/Fz was not significantly different between conditions for either limb of individuals poststroke (p=0.06 – 0.80).

Conclusions:
Minimizing postural demands affected GRF direction for nonimpaired individuals, but not for individuals poststroke. This suggests an interdependence between posture and locomotion in the nonimpaired nervous system, where postural information is necessary to adjust locomotor output. In contrast, minimizing postural demands did not appear to affect the neural strategy used to control GRF direction for individuals poststroke.
Why do some people acquire a novel motor skill with relative ease and efficiency, while others struggle and eventually fail? There are reports of individuals who are unable to learn even after extensive practice (Brooks et al. 1995). Our long-term goal is to discover a simple, accurate and reliable brain biomarker of motor learning capability; this would promote development of personalized training programs to foster motor learning in athletic and rehabilitation settings. Our primary aim in this study is to determine if resting-state electroencephalography (rs-EEG) can be used to predict motor learning capability in non-disabled individuals.

Methods:
Nineteen non-disabled adults (8 females, mean age 25.7 +/- 2.8 yrs) participated. We used a discovery learning task to discriminate if participants can discover the movement strategy that governed task success. We adapted the Brooks’ (1995) task—the objective is to use a thumb joystick to move a cursor from a start box to a stop box in ≤ 3 sec. Unknown to the participants, the coupling of joystick to cursor movement is determined through rate control, not typical position control. This required participants to search the environment for the right movement pattern. We measured their level of search by calculating the variance of the cursor movement during early performance. Participants practiced 200 trials of the task on Day 1 of the experiment and 50 retention trials on Day 2 (24 hours later). Prior to practice on Day 1, 5 min of rs-EEG were acquired using a 64 lead EEG cap. We used a support vector machine to determine which intercortical connectivity measures—previously recorded during pre-practice rs-EEG—were most predictive of early search.

Results:
Participants had a wide range of performance capabilities with some individuals capable of many successful trials and others with few to zero. However, the amount of search during early practice predicted the accuracy with which each participant could execute the task rule during late performance on Day 1 and retention on Day 2. Finally, the support vector machine demonstrated that connectivity between the contralateral dorsal prefrontal cortex, orbitofrontal cortex and the parietal cortex were most predictive of early search.

Conclusion:
Together, these results demonstrate that rs-EEG can predict motor learning capability in young non-disabled adults.
F48: The Effect of Time of Injury on Reach Kinematics in Pediatric Hemiplegia: Preliminary Findings

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Introduction:
Many activities of daily living require the ability to move the upper extremity freely through a workspace. Neurological injuries such as pediatric hemiplegia (PH) can sizably limit an individual’s independence with such tasks. PH results from injury to the developing brain before, during or soon after birth. An individual with PH can present with involuntary joint coupling between shoulder abduction (SABD) and elbow, wrist, and finger flexion, known clinically as the flexion synergy. The expression of the flexion synergy during reaching has been shown to increase with SABD loading in adults after stroke but has not yet been characterized in PH. Retention of high resolution ipsilateral corticospinal projections in earlier injuries may reduce the presence of involuntary joint coupling characteristic of adults after a stroke. The aim of this study is to quantify reach distance during a dynamic task as a function of SABD loading in PH. It is hypothesized that individuals with earlier injuries (PRE) will be able to reach farther at higher SABD loads compared to those with later injuries (PERI and POST).

Methods:
Participants included 5 individuals with PH (ages 10y-19y; 3 PRE, 1 PERI, 1 POST). Maximum voluntary SABD torque (MVT) was determined isometrically for each participant. Participants then completed a set of reaching tasks in the Arm Coordination Training 3-D (ACT3D) robot which allows arm movement in three dimensions. With the arm rigidly coupled to the robot, participants were instructed to reach forward towards a virtual target set near full arm extension. Each set of reaches required participants to lift their arm against different loads including full support on a haptic table and 20%, 35%, 50%, 65% and 80% of SABD MVT. To compare results between participants, reach distance was normalized to a percentage of maximum distance achieved on the table.

Results:
Percent change from the table condition to each SABD level was calculated for the paretic arm where a negative value indicates a decrease in distance. The mean change at 20% MVT was -4%±13% (PRE), -8% (PERI), and 2.5% (POST) and at 80% MVT was -12%±7% (PRE), -23% (PERI), and -51% (POST). These preliminary results show a decrease in reach distance at higher SABD levels with a trend towards greater deficits in individuals with later injuries.

Conclusions:
Use of retained ipsilateral corticospinal projections may enable the relative maintenance of reach ability seen across load levels in earlier injured individuals. In contrast, a reliance on more diffuse reticulospinal projections may explain the decreased reach ability seen in later injuries. Knowledge gained from further study will enable deeper understanding of neural pathways as well as the development of targeted therapies to address the underlying causes of motor impairments in subpopulations of PH.
Proprioception refers to the perception of limb motion or position and the orientation of one’s body in space. Proprioceptive deficits are exhibited in nearly 50% of all stroke survivors and is associated with poor upper limb motor function and impaired activities of daily living function. Thus, improving proprioception could serve as an additional route to enhance motor recovery after stroke. Here we evaluated whether a robot-aided somatosensory training regimen requiring active wrist movements administered without vision would improve proprioception and motor performance in adults with chronic stroke. METHODS: Twelve adults with chronic stroke were recruited (Age: median: 63 years, range: 42 – 74 years; Time after stroke: median: 12 months, range: 4 – 55 months; Fugl-Meyer Assessment – UE: median: 65 points, range: 42 – 66 points). Participants completed two training sessions in two consecutive days (total training time: 1 hour). A familiarization phase with vision was completed prior to training, while training was performed without vision. User grasped the robot handle and performed wrist adduction/abduction movements to tilt a virtual board on which a ball rolled. User’s aim was to roll the ball to a target on the board. Real-time, vibro-tactile feedback about joint position and velocity was provided to the forearm. Task difficulty increased with improvement in participants’ performance. Assessment was conducted before, immediately after, and two days after the intervention. Outcome measures were (1) wrist position sense acuity defined as the just-noticeable-difference (JND) threshold of wrist abduction/adduction, (2) the peak latencies of somatosensory-evoked potential (SEP) components induced by median nerve stimulation and (3) movement time and spatial error of a wrist pointing task using a computer mouse. RESULTS: (1) Compared to the pretest JND threshold significantly reduced at posttest (Wilcoxon signed-rank test: p = .0042) and retention (p = .0042) (Median JND threshold: Pretest: 1.8°, Posttest: 1.4°; Retention: 1.3°). 2) Delayed SEP components recorded at the frontal electrodes were found in participants with a JND threshold higher than 1.8° at pretest. However, intervention-related changes were insignificant. (3) Movement time reduced from pretest to posttest but the difference was insignificant (p = .064; Median time: Pretest: 11.4 s, Posttest: 10.7 s; Retention: 10.9 s). Compared to pretest, endpoint error in vertical direction reduced significantly at posttest (p = .016) but not at retention (Median: Pretest: 12.4 pixels, Posttest: 9.4 pixels; Retention: 10.1 pixels). CONCLUSION: A brief bout of a robot-aided proprioceptive training improved proprioceptive acuity and motor performance in chronic stroke participants. Proprioceptive impairment was related to delayed early proprioceptive processing but was not modified by the brief intervention. If the effectiveness on improving the proprioceptive and motor function is substantiated in a larger population, the proposed training could be a treatment approach for clinical practice.
F50: A Method for Gait Rehabilitation in the Clinic and at Home: Individualized Cueing and Feedback on Key Fall-Related Measures for Individuals after Stroke.

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No specific evidence-based method for maximizing gait recovery after stroke has been established as effective in making long-term improvements that translate to increased and safer community ambulation. Treadmill training and other intensive programs are effective for temporarily increasing speed and endurance but are often too expensive for home or community use. We have designed a simple system (named Veristride STEP-R) that can be used in a clinic or at home to provide practice opportunities of walking while adapting one’s gait towards parameters that are negatively related to fall risk. More specifically, we combine principles of external attentional cueing and implicit re-learning of functional muscle synergies with insole-based measurement of gait parameters and algorithms that deliver therapist-driven but individually targeted rhythmic auditory cues with intermittent feedback. We present two pilot studies each including individuals with chronic stroke.

Pilot 1 (n=9) tests the premise that delivering an auditory cue while walking (a dual-task) will not adversely effect the attention required to maintain a given speed during overground walking. After three trials of preferred speed walking, a metronome was set at their preferred cadence and the participant asked to time their footfalls with the beat. We found no change in stride velocity, stride length and stride time indicating that attention to the cue to reproduce the stride time did not detract from maintaining stride length and therefore stride velocity. Pilot 2 (n=5) evaluates the ability of the Veristride STEP-R to accurately measure gait variable targets in individuals with chronic stroke. Three key variables related to fall risk include step-length symmetry, stride-time consistency and stride-length at a given velocity. These gait variables were measured as the participants performed a 10 m walk at self-selected and fast walking speeds with concurrent data collection from a gaitmat. Preliminary results suggest that our system is reliable and valid. Since we have previously shown that these gait variables can be improved through the individualized manipulation of auditory cues after 12 weeks of lab-based training and were maintained at 12 weeks of retention, we now can begin testing the feasibility of Veristride Step-R in a clinic or home-based setting.
Background:
Most stroke studies enroll participants who are weeks or months post-stroke; these individuals have had much practice with their hemiparetic arm as well as motor therapies. In the Acute Assessment of the Hemiparetic Arm (AAHA) study, we aim to examine upper extremity (UE) motor behaviors in individuals before they have time to adapt to their altered motor control, learn compensatory strategies, and undergo motor training. We also aim to examine the relationship between these early motor behaviors and self-reported arm use in the community. Our study will further the description of human hemiparesis unmodified by spontaneous practice and therapy, and may provide clinicians new tools for treatment planning and recovery prediction.

Objective:
To assess a wide spectrum of stroke patients with varying impairment levels as early as possible, and no later than 7 days post onset. Assessments quantify UE impairment and abilities at the levels of single joint, multi-joint and spontaneous movements. These measures are compared with the participant’s motor performance and self-reported functional use at 30 days post stroke.

Methods:
Participants are recruited from Washington Hospital Center in Washington, DC, within 7 days. Assessments include single joint goniometry, Action Research Arm Test (ARAT), Fugl-Meyer UE measure and accelerometry. The accelerometers are placed bilaterally for 24-72 hours. Analyses include total movement counts and quantifying bilateral symmetric movement. Accelerometry data will be analyzed using machine learning techniques to determine the amounts of prehensile function use. Neglect and aphasia are measured using the Star Cancellation Test and the Frenchay Aphasia Screening Test. At 30 days, participants complete a Fugl Meyer, ARAT, Stroke Impact Scale and the Motor Activity Log.

Results:
Currently, 8 subjects have been enrolled; 4 have completed the 30 day assessment. Mean age is 62.25±17.01 years and 5 participants are male. The mean NIHSS score is 5.28±4 and the mean NIHSS affected arm item score is 1.14±1.07. Testing was initiated 4.63±1.67 days after onset; 7 participants had ischemic stroke. Average ARAT scores of the population are 30.75±22 and mean Fugl- Meyer is 38.88±20. Updated results and accelerometer data will be presented.

Conclusion:
It is possible to recruit and test individuals for UE movement within one week post stroke. Individuals tested thus far have a wide variety of impairments and abilities; more efforts are underway to capture more severely affected individuals to describe the full range of early motor severity.

Funding Source:
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F52: Unusual Case Presentation of a Cerebral Vascular Accident as an Isolated Internuclear Ophthalmoplegia

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Case Presentation:
A 56-year-old Caucasian male presented with acute blurred vision. Neurologic evaluation was consistent with a left internuclear ophthalmoplegia. No strength, sensory, or cerebellar abnormalities were found on neurological examination. Speech and language pathology evaluation revealed no functional deficits. Magnetic Resonance Image (MRI) of the brain was limited by a large amount of motion artifacts but demonstrated a remote basal ganglia infarct on the left and a diffusion restriction within the pontomedullary junction. Magnetic Resonance Angiography (MRA) did not reveal an aneurysm, major vessel occlusion, or high-grade stenosis. 2-D echocardiogram revealed mild concentric left ventricular hypertrophy with no ventricular wall motion abnormalities. Carotid duplex showed minimal atherosclerotic disease. No cardiac arrhythmias were discovered on the hospital's telemetry monitoring system. With prominent motion artifact on MRI, a subtle ischemic insult could not be ruled out and an acute infarct was considered the most likely diagnosis. The patient was started on a daily aspirin and statin medication for post-stroke prophylaxis. Ophthalmology recommended left eye patching for symptomatic relief of double vision. Once the patient was deemed medically stable, further inpatient rehabilitation services were offered but the patient declined. The patient subsequently was discharged home with Neurology follow-up. Two days after discharge, the patient fell leaving his apartment and was re-admitted for a right femoral neck fracture. A right hip hemiarthroplasty was performed by Orthopedic surgery. The patient was subsequently discharged to subacute rehabilitation for long-term rehabilitation management. The patient was then lost to follow-up.

Discussion:
This is the first reported care, to our knowledge, of a patient with an acute cerebral vascular accident who presented with an isolated internuclear ophthalmoplegia without evidence on MRI. Pure isolated unilateral internuclear ophthalmoplegia from ischemic cerebral vascular accident has only rarely been described.

Conclusion:
Internuclear ophthalmoplegia may manifest as an isolated finding of cerebral vascular accident.
Background:
Persistent post-stroke motor dysfunction can be influenced by impaired sensorimotor cortical activity and connectivity. Paired associative stimulation (PAS) can non-invasively increase corticomotor excitability through the coincident arrival of afferent sensory input from peripheral nerve electrical stimulation with activation of the primary motor cortex (M1) representation for a targeted muscle with transcranial magnetic stimulation (TMS) in neurologically intact individuals. However, there is limited evidence showing PAS can modulate corticomotor excitability in stroke survivors. Further, no studies have directly investigated the effect of PAS on measures of intracortical sensorimotor connectivity. The purpose of this pilot study was to investigate the effects of PAS on ipsilesional corticomotor excitability and intracortical sensorimotor connectivity between M1 and primary somatosensory cortex (S1) in stroke survivors.

Methods:
Seven individuals with chronic stroke completed two separate visits separated by at least one week. Each visit consisted of either a PAS or PASsham protocol. TMS assessments were performed at four time points with respect to the PAS protocol: PRE, POST0, POST30, and POST60 minutes. During the TMS assessments, electromyography (EMG) of the paretic abductor pollicis brevis (APB) and electroencephalography (EEG) of cortical activity were performed continuously during the delivery of 20 suprathreshold (~1mV) TMS pulses. Each PAS protocol consisted of 180 pairs of median nerve stimulation of the paretic extremity followed by suprathreshold (~1mV MEP amplitude) TMS over ipsilesional M1 with an inter-pulse interval based on the individual N20 latency+5ms delivered at 0.25Hz. The PASsham protocol was identical to the active PAS protocol, except the TMS coil was oriented orthogonal to the skull. EMG measures of general corticomotor excitability (MEP peak-to-peak amplitude) were extracted offline. Intrahemispheric EEG connectivity was calculated as the post-TMS (0-2000ms) imaginary part of coherency (IPC) value between electrodes (C3/C4 and CP3/CP4) overlying the upper extremity M1 and S1 representations of the ipsilesional hemisphere within the beta frequency range (15-30Hz). Change ratios (POST/PRE) were calculated for both MEP and IPC values.

Results:
There was a main effect of time ($F_{1,6}=5.01, p=.04$) on MEP change with an average 48% increase in MEP amplitude following PAS compared to a 3% increase following PASsham. For change in IPC value, there was a trend towards a session-by-time interaction ($F_{1,6}=4.27, p=.10$), where IPC increased following the PAS session but not following PASsham. We observed a non-significant trend towards a negative relationship between PRE IPC values and change in IPC in response to PAS (POST0, $r=.60, p=.12$; POST30, $r=.65, p=.11$; POST60, $r=.58, p=.14$).

Discussion:
Preliminary findings suggest that PAS can increase levels of intrahemispheric connectivity between ipsilesional M1 and S1 in stroke survivors. Further, baseline intrahemispheric sensorimotor connectivity may be associated with individual PAS response. Future research will determine if PAS-induced changes in ipsilesional intrahemispheric sensorimotor connectivity can promote improvements in motor function and reduce persistent impairment after stroke.
Background.
Corticospinal tract (CST) fractional anisotropy (FA) asymmetry between hemispheres is a significant predictor of motor recovery in acute and subacute post-stroke individuals. However, we lack evidence if the CST FA asymmetry also can predict motor behavior improvement after an upper extremity (UE) motor therapy in chronic stroke survivors with mild-to-moderate motor impairment who are targeted by several clinical trials.

Purpose.
This study aims to determine feasibility of prediction model using CST FA asymmetry to estimate improvement in motor behavior after a 3-month upper extremity motor therapy in chronic stroke survivors with mild-to-moderate motor impairment.

Methods.
This study is a part of a longitudinal phase-I clinical trial of rehabilitation in chronic stroke (ClinicalTrials.gov ID: NCT 01749358). Chronic stroke survivors with mild-to-moderate motor impairment participated (N=37, average chronicity = 3.01±3.08 years). They completed clinical motor behavior and neuroimaging assessments in two different time points with 3-month period between two time points. Participants received upper extremity motor therapy during the 3-month period with different doses. We used Wolf Motor Function Test log mean time score for distal control tasks to represent motor behavior. Neuroimaging assessments consist of T1-weighted imaging and diffusion tensor imaging. Imaging data were co-registered using BrainSuite16a1 (http://brainsuite.org/). Diffusion tensor-based CST tractography was reconstructed for each hemisphere, and mean FA for each 3-dimensional CST volume was calculated. The CST FA asymmetry was calculated as \([\text{contralesional CST FA} - \text{ipsilesional CST FA}] / [\text{contralesional CST FA} + \text{ipsilesional CST FA}]\). Simple linear regression was used to test if baseline CST FA asymmetry can predict changes in WMFT time score after UE motor therapy. Further, lasso regression with leave-one-out cross-validation was used to regularize and select most important clinical and imaging predictors of changes in motor behavior. In lasso regression, predictor variables included clinical motor outcome scores, demographic information, and neuroimaging variables including CST FA asymmetry. The dependent variable was change in WMFT log mean time score for distal tasks.

Results.
CST FA asymmetry explains 19% of variance in change in WMFT time score. Age, FM, SIS-hand, and CST FA asymmetry were selected as significant predictors of change in WMFT time score from cross-validated lasso regression. The predicted WMFT time score from the lasso regression model explained 38% of variance in the actual change in WMFT time score. Further, the beta value of CST FA asymmetry was greater than other predictor variables’ beta values in this model.

Discussion.
CST FA asymmetry is a significant predictor of improvement in motor behavior in chronic stroke survivors with mild-to-moderate motor impairment. Further, lasso regression with cross-validation can be used to develop a more accurate and robust prediction model with significant imaging, demographic, and clinical motor behavior biomarkers.
F55: Command Following Assessment and Communication with Vibrotactile P300 and Motor Imagery Brain-Computer Interface Technology in Locked-In and Completely Locked-In Patients

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Many patients with locked-in syndrome (LIS) or complete locked-in syndrome (CLIS) also need brain-computer interface (BCI) platforms that do not rely on visual stimuli and are easy to use. We investigate command following and communication functions of mindBEAGLE with 9 LIS, 3 CLIS patients and three healthy controls. These tests were done with vibrotactile stimulation with 2 or 3 stimulators (VT2 and VT3 mode) and with motor imagery (MI) paradigms. In VT2 the stimulators are fixed on the left and right wrist and the participant has the task to count the stimuli on the target hand in order to elicit a P300 response. In VT3 mode an additional stimulator is placed as a distractor on the shoulder and the participant is counting stimuli either on the right or left hand. In motor imagery mode the participant is instructed to imagine left or right-hand movement. VT3 and MI also allow the participant to answer yes and no questions. Healthy controls achieved a mean assessment accuracy of 100% in VT2, 93% in VT3, and 73% in MI modes. They were able to communicate with VT3 (86.7%) and MI (83.3%) after 2 training runs. The patients achieved a mean accuracy of 76.6% in VT2, 63.1% in VT3, and 58.2% in MI modes after 1-2 training runs. 9 out of 12 LIS patients could communicate by using the vibrotactile P300 paradigms (answered on average 8 out of 10 questions correctly) and 3 out of 12 could communicate with the motor imagery paradigm (answered correctly 4,7 out of 5 questions). 2 out of the 3 CLIS patients could use the system to communicate with VT3 (90 and 70% accuracy). The results show that paradigms based on non-visual evoked potentials and motor imagery can be effective for these users. It is also the first study that showed EEG-based BCI communication with CLIS patients and was able to bring 9 out of 12 patients to communicate with higher accuracies than reported before. More importantly, this was achieved within less than 15-20 min.
F56: A Systematic Review: Does Cathodal Transcranial Direct Current Stimulation Over Contralesional Motor Cortex Enhance Upper Limb Motor Recovery Post-Stroke?

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Background
During recovery from stroke, contralesional motor cortex (cM1) may undergo maladaptive neuroplastic changes. The application of cathodal transcranial direct current stimulation (tDCS) to cM1 may down-regulate this maladaptive plasticity and enhance motor recovery. However, individual response differences to tDCS may impact the clinical utility of this approach.

Objective
To evaluate the evidence that tDCS with the cathode over contralesional M1 enhances motor re-learning or recovery post-stroke.

Methods
We performed a systematic review in accordance with PRISMA guidelines. We searched the following databases in collaboration with a librarian (HL), limited from the year 1990: MEDLINE (1946-June 2015), Embase (1947- June 2015), and Cochrane (May 2015). Articles were included if they met the following criteria: 1) Participants: Individuals with hemorrhagic or ischemic stroke, > 18 years of age and > 1 week post-onset, with motor impairment to the upper limb; 2) Intervention: tDCS with the cathode over cM1 and anode over the contralateral supraorbital area, applied offline or online with any intervention for the upper limb; 3) Comparison: Sham tDCS; 4) Outcomes: Change in any clinically validated assessment of physical function, activity or participation, or change in a movement performance variable (i.e. movement time, accuracy); 5) Time: One or more sessions of the intervention; 6) Trial design: randomized clinical trials, controlled clinical trials, and pre-post trials; 7) Type of publication: Articles published in English and peer-reviewed. Two investigators (JLC, AS) independently evaluated the articles to determine eligibility. Two investigators (JLC, JE) independently rated eligible articles for methodological quality according to the PEDro Scale.

Results
We identified 1589 potential articles, thirteen met eligibility criteria. The PEDro scores ranged from 6 to 11 (max = 11). Five studies were randomized controlled trials (7 to 13 participants tested in each arm, one study tested 32 per arm), and eight studies used a cross over design (3 to 13 participants tested) probing effects of single session tDCS. A variety of outcomes measures and stimulation parameters were used precluding the pooling of data. Eight out of thirteen studies showed a significant effect of cathodal versus sham tDCS. It is unclear whether factors such as stage of stroke (sub-acute vs chronic), timing of tDCS (online vs offline), and number of sessions (single vs multiple), influenced the outcome. The RCT with n=32 per arm showed no effect; severely impaired sub-acute stroke participants underwent robot-assisted training with online tDCS.

Discussion
Studies with small sample sizes show modest evidence that cathodal tDCS to cM1 may enhance aspects of motor performance. The large RCT tested severely impaired participants and showed no effect. Based on recent evidence, these individuals may not benefit from cathodal tDCS to cM1. Recommendations include the need for harmonization of outcomes and stimulation parameters, and more adequately powered studies.
F57: Use of a Novel Tele-rehabilitation Format to Provide Physical Therapy Exercise to Veterans with Multiple Sclerosis

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Multiple Sclerosis (MS) is the most common progressive neurological condition of young adults and affects approximately 400,000 people in the United States. It has primary and secondary consequences on mobility and ambulation across the lifespan. Physical rehabilitation is one of the few non-pharmaceutical options effective in improving walking ability. However, substantial barriers related to neurological disability, travel distance, and scheduling impede access. Remote tele-rehabilitation offers an avenue to improve access to specialized rehabilitation services. The primary objective of this study was to assess the feasibility and patient acceptance of a home automated tele-management (HAT) system to delivery remote rehabilitative therapies to Veterans with Multiple Sclerosis (MS).

Methods:
Patients (n=24) were randomized to either routine home rehabilitation or to the MS HAT program for a 6 month period. The MS HAT group (n=16) had a mean age of 50.4 years, 56% of patients were male, and 67% had progressive MS with an overall mean Patient Determined Disease Steps score of 4.4 (cane or crutch required for walking). Key outcomes included the timed 25-foot-walk (T25W), 6-minute-walk (6MW).

Results:
There was no significant difference in the change on the primary walking outcome measure (T25FW) at month 6 between the MS HAT intervention and control group (p=0.44). Similarly, the 6 month change scores for the 6MW were not significantly different. Exercise adherence defined as 45% or more days of HAT exercise log-ins over the course of the intervention occurred in eight out of the sixteen MS HAT participants.

Conclusion:
This population with predominately progressive MS maintained their overall gait abilities over a 6 month period using either a web-based tele-rehabilitation program or a traditional home exercise program. Exercise adherence in the MS HAT group was positively associated with higher MS disability and post-intervention self-reported walking ability.
F58: Altered Functional Connectivity Differs in Stroke Survivors with Tactile Impairment Following Left and Right Hemisphere Lesions.

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Background:
One in two survivors experience impairment in touch sensation after stroke. The nature of this impairment is likely associated with changes within intrinsic functional somatosensory networks within the brain; however few studies have examined this. In particular, the impact of lesioned hemisphere has not been investigated. We hypothesised altered functional connectivity relative to healthy controls in survivors with left compared right hemisphere lesion. In addition we expected disrupted connectivity between homotopic somatosensory regions.

Method:
We examined resting state functional connectivity in 28 stroke survivors, 14 with left hemisphere and 14 with right hemisphere lesion, and 14 healthy controls. Contralesional hands showed significantly decreased touch discrimination ability. Whole brain functional connectivity (FC) data was extracted from four seed regions, i.e. primary (S1) and secondary (S2) somatosensory cortices in both hemispheres. Whole brain FC maps and Laterality Indices (LI) were derived for subgroups.

Results:
Interhemispheric FC was greater in healthy controls compared to the combined stroke cohort from the left S1 seed and bilateral S2 seeds. The left lesion subgroup showed decreased FC, relative to controls, from left ipsilesional S1 to contralesional S1 and to distributed temporal, occipital and parietal regions. In comparison, the right lesion group showed decreased connectivity from contralesional left S1 and bilateral S2 to ipsilesional parietal operculum (S2), and to occipital and temporal regions. In addition, the right lesion group showed increased intrahemispheric FC from ipsilesional right S1 to inferior parietal regions compared to controls. When compared to the left lesion group, those with right lesions also showed greater intrahemispheric connectivity from left S1 to left parietal and occipital regions and from right S1 to right angular and parietal regions. Laterality Indices were significantly greater for stroke subgroups relative to matched controls for contralesional S1 (left lesion group) and contralesional S2 (both groups).

Conclusion:
We provide evidence of altered functional connectivity within the somatosensory network, across both hemispheres, and to other networks in stroke survivors with tactile impairment. Moreover, hemisphere of lesion was associated with different patterns of altered functional connectivity within the somatosensory network and with related functional networks.

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Introduction:
Diffusion magnetic resonance imaging (dMRI) has played an important role in visualizing white matter structures in stroke. This technique has the potential to image post stroke changes attributed to recovery. Current studies have produced structural networks images with dMRI post stroke at a relatively large resolution (e.g. 2.5 mm isotropic). This limits our ability to visualize any smaller changes in white matter structures that are more likely to take place due to recovery. Track density imaging (TDI) is a novel method that enables higher resolution images of white matter structures to be processed from standard dMRI acquisition.

Aim:
We aim to use track density imaging to visualize white matter and surrounding structures, inclusive of lesion regions, at high resolution in stroke survivors.

Method:
Thirteen stroke patients with significant sensory impairment, as defined using the Tactile Discrimination Test (TDT), were identified from the Connecting New Networks for Everyday Contact through Touch (CoNNECT) trial. Patients were scanned at 3 different time points with sensory rehabilitation training implemented between scans, making this dataset ideal for visualizing any white matter changes linked to recovery. All participants were at least 3 months post stroke and right handed. We used TDI to process data in patients with cortical and subcortical lesions that led to sensorimotor impairment. Diffusion MRI data were preprocessed with MRTRIX3 software. This allowed for the definition of the different brain tissue types (5 tissue type – 5TT) including the lesion region, and using the spherical deconvolution informed filtering of tractograms (SIFT2) approach to create whole brain white matter tractograms. Higher resolution (1mm) TDI maps were then created from these SIFT2 tractograms. Fractional anisotropy (FA) maps were also created from the same datasets to compare the two contrasts.

Results:
We achieved TDI maps with a resolution of 1mm isotropic from 2.5mm isotropic dMRI data. All TDI maps show superior detail when compared to the FA maps. FA maps were maintained at a resolution of 2.5 mm whilst TDI maps were created with a 1mm isotropic resolution. The TDI maps also unveil finer structures within the thalamus regions of subcortical lesioned patients compared to the FA maps. Incorporating the 5TT processing of patient data allowed for visualization of surviving white matter structures within the lesion area.

Discussion and conclusion:
We show for the first time the use of a novel processing method to achieve high resolution visualization of white matter structures in stroke patients. This high resolution visualization of white matter is valuable in moving forward our understanding of neuroanatomical reorganization that may take place in stroke recovery. This contrast image is shown to be far superior to the more common FA maps that are most commonly utilized to understand white matter anatomy in stroke.
Severe acute malnutrition (SAM) affects 20 million people worldwide presenting as either edematous kwashiorkor, or non-edematous marasmus. The long-term effects of SAM that occurred during infancy persist through adulthood and can translate to psychosocial, behavioral, and cognitive dysfunction, although little is known about the effects on brain physiology. Therefore, the purpose of the study was to assess executive function in adult survivors of SAM using a psychophysiological level of analysis. A 64-channel EEG system (BrainVision) recorded the electrical activity of the brain in 7 Jamaican adult kwashiorkor survivors, 6 marasmus survivors, and 10 community controls while performing computerized cognitive testing. Specifically, the Erikson Flanker task was used as it serves as an index of inhibition, a domain of executive function. In this task there are two types of trials, congruent and incongruent. Incongruent trials are more difficult as they require the inhibition of competing stimuli resulting in longer reaction times. The EEG data were low pass filtered at 15 Hz and artifacts were reduced using Independent Component Analysis. The data were then epoched -100 – 900 ms around when the arrows were presented. Finally the epochs were separated based on trial type and averaged across trials for both the congruent and incongruent stimuli. Two notable EEG outcome measures were the N2, which serves as an index of perceived conflict and the P3 which indexes stimulus categorization. As expected, the control subjects exhibited a delayed and reduced amplitude of the P3 response reflecting a well characterized phenomena that incongruent stimuli elicit delays in the ability to categorize the stimuli. However the kwashiorkor and marasmus individuals exhibited markedly reduced P3 responses relative to controls, irrespective of stimulus type suggesting they have an impaired ability to categorize the trials with and without the presence of conflicting information. This phenomena was more pronounced in those with marasmus. Additionally, for kwashiorkor and marasmus, the N2 was larger in congruent and incongruent trials compared to controls, suggesting greater perception of conflict regardless of the presence of conflicting visual information. These data provide psychophysiological evidence that both kwashiorkor and marasmus individuals have impaired cognitive functioning.
F63: Virtual reality reduces subjective chronic neuropathic pain scores in people with spinal cord injury

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Introduction:
Chronic neuropathic pain is an unrelenting and debilitating condition that affects up to 70% of people with spinal cord injury (SCI) and severely impacts their quality of life. The effects of available treatments are limited, and attempts at pharmaceutical management can often lead to drug dependencies. Therefore, there is a critical need to develop a new generation of therapies. Virtual reality (VR) uses advanced computer graphics to create artificial environments that appear to be visually realistic. Emerging literature suggests that VR may be a viable therapy for many neuropathic pain sufferers, but little is known about the specific features of the virtual environment that result in the pain reduction effect.

Methods:
We recruited 12 individuals with chronic spinal cord injury, with presence of chronic neuropathic pain of the arms or legs. Subjective pain scores were collected using a visual analogue scale (VAS) prior and immediately after to exposure to 5 minutes of custom-designed VR environment protocol. Differences in pre- and post-VR VAS scores were assessed for statistical significance using a paired t-test.

Results:
Participants reported an average baseline pain intensity of 5 (±1.2) (mean ± standard deviation). Following exposure to our custom VR environment, average pain intensity was reduced by 1.5 points to an average pain intensity of 3.5 (±2). These differences were statistically significant (p<0.02).

Conclusions:
The results of this pilot study indicate that a short-duration exposure to VR environments can have a significant effect on chronic neuropathic pain intensity. Further research needs to be conducted in order to better understand generalizability and scalability of this innovative approach to treating neuropathic pain in a much larger population of individuals with SCI.
Background and Aim:
Spasticity occurs in children with cerebral palsy and often hinders the motor functions or causes pain. Both neural and non-neural changes in children with CP contribute to the felt-resistance related to spasticity and each may respond differently to treatment options. A quantitative and clinical relevant assessment tool is relevant to enhance treatment outcomes. The objective of this study is to correlate two quantitative ways to characterize spasticity to the Tardieu Scale, a clinical measure of spasticity.

Participants:
Seventeen children with CP (6 females and 11 males aged at 10.66yr±3.92) were recruited in the study from two collaborative sites. All had spasticity at the ankle joint at the time of recruitment. None of them had orthopedic surgery in the study limb or received botulinum toxin type A injection in the six months prior the study.

Methods:
An instrumented tendon tapper and a single-joint robotic device were used to characterize spasticity in the isometric condition and during the passive stretching at slow (60 deg/sec) and fast (90, 180 and 210 deg/sec) speeds, respectively. Each participant was evaluated by experienced physicians using the Tardieu scale. Pearson correlation test was used to correlate instrument-based evaluation paraments (tendon reflex gain, contraction time, contraction rate, half-relaxation time, half-relaxation rate, phasic and tonic reflex torque at various speeds, and joint stiffness) to clinical measures (Tardieu spasticity angle (R2-R1), R1, R2, ratio of Tardieu spasticity angle to R2).

Results:
Significant correlations were found between instrument-based measures and clinical measures. Tendon reflex torque, half relaxation time and contraction rate are negatively correlated to R2 angle (p= 0.03, 0.01 and 0.02, respectively) while half-relaxation time and contraction rate are also negatively correlated to R1 angle (p= 0.04 and 0.02 respectively). Through passive stretching, tonic reflex torque at higher speeds (90, 180 and 210 deg/sec), viscous damping at higher speeds (180 and 210 deg/sec) and stiffness are positively correlated to ratio of Tardieu spasticity angle to R2 (p= 0.02, 0.01, 0.03, 0.03, 0.04, and 0.01, respectively). Tonic reflex torque and viscous damping at 180 deg/sec and stiffness are positively correlated to Tardieu spasticity angle (p= 0.02, 0.04 and 0.04 respectively).

Conclusions:
The greater the R2 and R1 angle, the less the tendon reflex gain and other measures derived from instrumented tendon taping in the isometric condition. The greater the Tardieu spasticity angle, the higher the tonic reflex torque, viscous damping and stiffness derived from passive stretching. Furthermore, if the spasticity angle covers the most of R2, we would observe higher tonic reflex torque and viscous damping at high speeds as well as the higher stiffness. The findings suggest that the instrument-based spasticity measures represent and quantitate the Tardieu scale to characterize the reflex and non-reflex components of spasticity.
F65: Does Tonic Inhibition in the Sub-Acute Period After Stroke Alter the Trajectory of Upper Limb Recovery?

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Background:
Evidence from experimental animal models of stroke indicates that reducing the level of tonic inhibition present in motor cortex may facilitate neural plasticity, learning, and motor recovery. The present study is examining primary motor cortex (M1) inhibition in patients over the first 12 weeks after stroke, and in a cohort of age-similar healthy controls.

Methods:
Gamma aminobutyric acid (GABA) concentration and neurotransmission in M1 are assessed using magnetic resonance spectroscopy (2 and 6 weeks after stroke) and threshold tracking paired-pulse transcranial magnetic stimulation (TMS) (2, 6, and 12 weeks after stroke). Upper limb impairment is assessed with Fugl-Meyer Upper Extremity Scale at 2, 6, 12 and 26 weeks after stroke.

Results:
Similar to recent studies, patients with a functionally intact corticospinal pathway exhibit a proportional recovery such that upper limb impairment resolves by ~70% of the maximum possible. MRS indicates that compared to age-similar controls, GABA concentration are reduced within contralesional, but not ipsilesional, M1 6 weeks after stroke. Short- and long-latency intracortical inhibition examined with TMS indicate greater inhibition in the ipsilesional hemisphere during the spontaneous recovery period after stroke compared to controls. Patients with higher tonic inhibition in ipsilesional M1 tend to have a longer recovery period. The extent of postsynaptic GABAergic inhibition is similar to controls during the early spontaneous recovery period, but disinhibition is present by 12 weeks post-stroke.

Conclusion:
The ability to modulate tonic inhibition levels early after stroke may have implications for upper limb recovery during the spontaneous recovery period.
Stroke is a leading cause of adult long-term disability worldwide, with up to two-thirds of individuals experiencing long-term disabilities. Large-scale neuroimaging studies have shown promise in identifying robust biomarkers (e.g., measures of brain structure) of stroke recovery. However, analyzing these large datasets is problematic due to barriers in accurate stroke lesion segmentation. Lesion segmentation allows us to account for the size, location and number of each individual’s lesions and to understand how these factors impact recovery. Manually traced lesions are the gold standard for lesion segmentation, but require anatomical expertise and can be prohibitively time consuming. While algorithms have been developed to automate this process, the results often lack accuracy. Promising newer algorithms employ machine learning techniques, but these require large training datasets to optimize performance. To address these issues, we developed ATLAS (Anatomical Tracings of Lesions After Stroke) Release 1.1, a publically-available dataset of 306 T1-weighted MRIs with manually segmented lesion masks and metadata. This large, diverse dataset can be used to train and test lesion segmentation algorithms and provides a standardized dataset for comparing the performance of different segmentation methods, and we hope ATLAS R1.1 will be a useful resource to assess and improve the accuracy of current lesion segmentation methods.

ATLAS lesions were traced by a team of 11 individuals. All team members were trained by an expert tracer on an identical set of lesions and followed detailed written and video protocols. We assessed inter- and intra-rater reproducibility by averaging the dice correlation coefficient (DC) between and within tracers, across the lesion training set (inter-rater DC = 0.76±0.14; intra-rater DC = 0.84±0.09). All lesion segmentations were quality checked by a second tracer. An experienced neuroradiologist reviewed all lesions to create metadata, including the number and location of lesions (left/right hemisphere; cortical/subcortical), type of stroke (ischemic, hemorrhagic), primary stroke location, vascular territory, and severity of periventricular and deep white matter hyperintensities. This metadata allows for sorting of the ATLAS dataset based on specific categories of stroke, and provides lesion characteristics during the evaluation of algorithms (e.g., an algorithm might fail primarily on cortical lesions, or in brains with multiple lesions, etc.).

ATLAS is deposited on the Archive of Data on Disability to Enable Policy (ADDEP) at the Inter-university Consortium for Political and Social Research (ICPSR). ICPSR is the world’s largest social science data archive that supports several substantive-area archive collections including disability and rehabilitation. We anticipate that ATLAS will become a useful resource to standardize the segmentation protocol, and improve the accuracy of current lesion segmentation methods. The full archived dataset, including both native and standardized datasets, will soon be available at http://www.icpsr.umich.edu/icpsrweb/ADDEP/studies/36684.